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Comparison of Surgically Induced Astigmatism between Straight and Frown Incisions in Manual Small Incision Cataract Surgery

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Abstract

The type of incision is the major contributory factor to the postoperative astigmatism. Different incisions may cause different degrees of astigmatism. It becomes imperative to compare the SIA caused by the commonly used incisions like straight and frown incisions. *Objectives:* To evaluate and document the best corrected visual acuity and surgically induced astigmatism in patients undergoing manual small incision cataract surgery by straight incision and frown incision. To compare the surgically induced astigmatism following straight and frown incision. *Materials and Methods:* For this prospective study a total of 96 eyes fulfilling the inclusion criteria were selected and allotted into two groups by simple randomization technique. Group1 – 48 patients – underwent MSICS with straight incision. Group2 – 48 patients – underwent MSICS with frown incision. This study was conducted in the department of ophthalmology at R. L. Jalappa Hospital and Research, Kolar attached to Sri Devaraj Urs Medical College, between January 2018 and May 2019. Post-operative visual acuity was assessed with Snellen's chart. surgically induced astigmatism was calculated using SIA calculator version 2.1. *Results:* The uncorrected visual acuity of group 2 was better when compared to group 1. 13(27.1%) patients achieved postoperative emmetropia in straight incision group while 24 (50%) patients achieved post operative emmetropia in frown incision group. All patients achieved a BCVA of ≥ 6/18. The mean magnitude of preoperative astigmatism in straight incision was 1.26± 0.92 D and in frown incision was 0.98 ± 0.83 D. The mean magnitude of postoperative astigmatism in straight incision was 1.52±1.17 D and in frown incision was 0.99 ± 0.82D and was found to be statistically significant, p= 0.012. The centroid of SIA for straight incision was 1.4x1° with a coherence of 90% and the centroid of SIA for frown incision was 0.62x2° with a coherence of 70%. *Conclusion:* The visual outcome of frown incision group was slightly better than the visual outcome in straight incision group. All patients achieved a BCVA ≥ 6/18. The difference in visual acuity was not found to be statistically different. The SIA of straight incision was significantly more than that of frown incision. (p=<0.001).

Keywords: SIA; SICS; Postoperative astigmatism; Straight incision; Frown incision; MSICS.

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Introduction

An estimated 36 million people are blind, three quarters of which is caused by senile cataract.[1] In India and in other developing countries senile cataract is the leading cause of avoidable blindness.

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Manual small incision cataract surgery (MSICS) is the most widely used method for cataract surgery in developing countries.[2] The factors influencing the visual outcome in manual small incision cataract surgery include, biometry, grade of cataract, post-operative astigmatism and surgeon's factor.[3] One of the important factors influencing visual outcome is surgically induced astigmatism (SIA). Surgeons aim at achieving post-operative emmetropia by reducing SIA which can contribute to a low visual outcome. SIA can be controlled by proper analysis of keratometric values pre-operatively, planning the incision size, type of incision and site of incision.[4]

The type of incision is a very important contributory factor to the post-operative astigmatism. Different incisions may cause different degrees of astigmatism. It becomes imperative to compare the SIA caused by the commonly used incisions like straight and frown incisions. Studies done comparing the SIA of frown and straight incisions gives a conflicting picture.[4,5] Studies give varied results as regards the post-operative astigmatism. Thus, a comparative study between frown incision and straight incision in manual small incision cataract surgery (MSICS) with posterior chamber intraocular lens implantation (PCIOL) is being conducted to facilitate the patient's post-operative vision. In this study we aim to evaluate and compare the uncorrected visual acuity and best corrected visual acuity between straight and frown incision and to compare the SIA between straight and frown incision using SIA calculator 2.1.

Materials and Methods

Source of Data

For this prospective study a total of 96 eyes fulfilling the inclusion criteria were selected and allotted into two groups by simple randomization technique (48 eyes in each group). This study was conducted in the department of ophthalmology at R. L. Jalappa Hospital And Research, Kolar Attached To Sri Devaraj Urs Medical College, between January 2018 and May 2019. All patients between the age group of 40–70 years undergoing MSICS with PCIOL implantation were included in this study. Those with corneal disorders like corneal opacity, degenerations and dystrophies, high myopia with thin sclera, primary or secondary glaucoma, scleral disorders like scleromalacia, scleritis, subluxated lens, history of previous ocular surgeries, traumatic cataract, hypermature cataract were excluded from our study.

Method of Collection of Data

All patients in this study underwent similar protocol. Informed consent was taken for all patients who participated in this study as per the standard protocol. Standard clinical examination which included recording of visual acuity with Snellen's chart, Goldmann Applanation tonometry, slit lamp examination, lacrimal syringing, and fundus evaluation were performed for all patients. Routine blood investigations were done for all participants in this study which included CBC, RBS, HIV, HBsAg, blood urea, serum creatinine.

Preoperative keratometry was measured by using a standard calibrated manual Bausch and Lomb keratometer. Axial length was measured using standard Ultrasound A-Scan, IOL power calculation is done using Sanders-Retzlaff-Kraff formula II (SRK II).

Similar protocol for preoperative preparation was done for all patients. All patients received Xylocaine test dose, oral tab ciprofloxacin 500mg twice daily and ciprofloxacin 0.3% eye drops 4 times per day one day before the surgery. Before the start of surgery, the pupil was dilated with a combination of tropicamide 0.8% with phenylephrine 5% drops. Flurbiprofen 0.03% drops was used to maintain mydriasis.

All patients underwent MSICS within the bag PC IOL implantation by a single surgeon. Out of the 96 patients in the study, 48 each patients were randomly divided into Group 1 and 2. The straight incision of 6mm which was 2mm from the superior limbus was used in Group 1 and a frown incision of 6mm with the apex of the incision 1.5 mm from the superior limbus and ends of the two limbs 4mm from the limbus was used in Group 2.

Similar protocol for postoperative care was followed for all patients. Post operative medications included tab ciprofloxacin 500mg given orally twice daily, a combination of ciprofloxacin 0.3% and dexamethasone 0.1% eye drops used for 6 weeks in a tapering dose. Postoperative corneal oedema was treated with sodium chloride 5% eye drops 4 times per day. Cycloplegics like Homatropine 2% and antiglaucoma medications like timolol 0.5% drops were given when required.

Postoperative follow up examination was conducted on day 1, 1st week, 4th week and 6th week. At each visit uncorrected visual acuity (UCVA), best corrected visual acuity (BCVA), careful slit lamp examination and keratometrywere performed.

The magnitude of astigmatism was classified according to Holmstrom's gradation.[6]

- No astigmatism, when <0.25D.
- Non-significant, when it is ≥0.25 and <1.0D.
- Significant, when it is ≥1.0D and <2.0 D.
- High, when it is ≥ 2 D.

The axes of astigmatism were divided into 3 classes.

- With the rule (minus cylinder at 180^{o} ± 20^{o} or plus cylinder at 90^{o} ± 20^{o}).

- Against the rule (minus cylinder at 90° ± 20° or plus cylinder at 180° ± 20°).
- Oblique.

SIA calculator version 2.1 by Dr Saurabh Sawhney and Dr Aashima Aggarwal was used to calculate the surgically induced astigmatism.[7] The keratometric values were converted to the plus cylinder formats to obtain the requires preoperative and post-operative astigmatism. This data was entered in the SIA calculator which analysed the data using the Cartesian coordinate analysis. It generates an x and y coordinate for each value of astigmatism using the formulae x=a cos 2p and y=a sin 2p, where a represents the magnitude of astigmatism and y represents the axis of steeper meridian. X_{pre} was subtracted from X_{post} and Y_{pre} was substracted from Y_{post} to obtain X_{SIA} and Y_{SIA}.

Magnitude of SIA was obtained by using the formula SIA magnitude=$(X_{SIA}^2+Y_{SIA}^2)$. The angle of SIA θ was obtained by the formula θ=0.5 x arctan(Y_{SIA}/X_{SIA}). The centroid value was obtained by finding the mean of the preoperative and postoperative astigmatism in X and Y format. $X_{mean(pre)}$ was substracted from $X_{mean(post)}$ and $Y_{mean(pre)}$ was substracted from $Y_{mean(post)}$ to obtain $X_{meanSIA}$ and $Y_{meanSIA}$.

The magnitude of centroid was then obtained by using the formula, magnitude of centroid of SIA=$[X_{meanSIA}^2+Y_{meanSIA}^2]^{1/2}$. The angle of the centroid value was obtained by θ = 0.5 x arctan $(Y^{meanSIA}/X_{meanSIA})$. Similarly, the centroid of preoperative and postoperative astigmatism was also be obtained. All centroid values thus obtained were in the plus cylinder format.

Astig MATIC, an application which uses Alpins vector analysis method was used to obtain single angle vector plots of the SIA vector.[8,9]

Statistical Analysis

Collected data was entered into an Excel spreadsheet with all the quantitative measures like preoperative astigmatism, postoperative astigmatism, SIA was presented by mean and standard deviation with confidence interval and qualitative data by proportions. Student t test/Mann Whitney U test was used to compare the difference of means. Chi square test was used for testing difference in proportion. Simple linear regression was used to find out the difference in astigmatism and best corrected visual acuity between the two groups. p value less than or equal to 0.05 was considered as statistically significant.

Results

Our study consisted of 96 subjects of which 59 (61.5%) were females and 37 (38.5%) were males. Group 1 consisted of 29 females (60.4%) and 19 males (39.6%) and group 2 consisted of 30 females (62.5%) and 18 males (37.5%) (Table1).

Table 1: Gender Group Crosstabulation.

Gender	Group		Total
	Straight Incision (group 1)	Frown Incision (group 2)	
Females	29(60.4%)	30(62.5%)	59(61.5%)
Males	19(39.6%)	18(37.5%)	37(38.5%)
Total	48(100%)	48(100%)	96(100%)

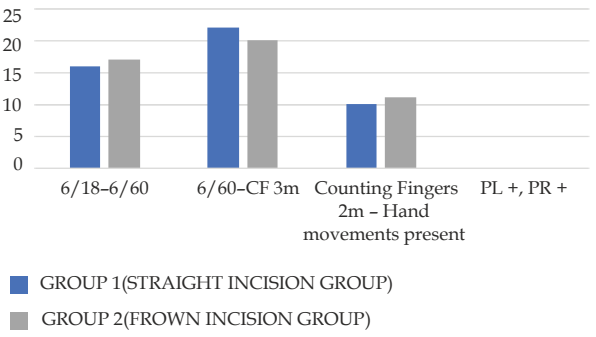
Preoperatively, majority of patients, 22(46%) patients in group 1 and 20(42%) patients in group 2 had UCVA between 6/60 and CF 3m. 16(33%) patients in group 1 and 17(35%) patients in group 2 had UCVA between 6/18 and 6/60. 10(21%) patients and 11 (23%) patients had visual acuity between CF 2m and HM+. There was no difference in the preoperative UCVA between both the groups (Table 2, Graph 1).

Table 2: Comparison of preoperative uncorrected visual acuity between straight and frown incision.

Preop Ucva	Group 1 (Straight Incision Group)		Group 2 (Frown Incision Group)	
	Number of Patients	%	Number of Patients	%
6/18–6/60	16	33%	17	35%
6/60–CF 3m	22	46%	20	42%
CF 2m – HM +	10	21%	11	23%
PL +, PR +	–	–	–	–
Total	48	100%	48	100

%– PercentagePL– Perception of light
CF– Counting FingersPR– Projection of rays
HM– Hand movements

Graph 1: Bar diagram showing comparison of preoperative uncorrected visual acuity between both the groups.



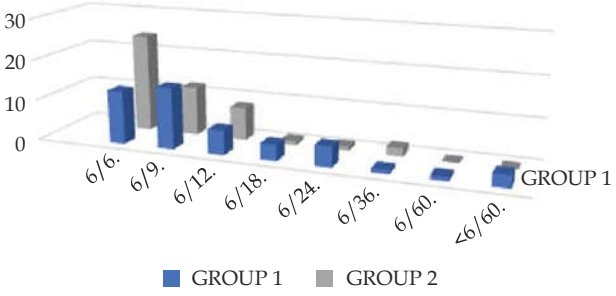
13(27.1%) patients achieved postoperative emmetropia in straight incision group while 24 (50%) patients achieved postoperative emmetropia in frown incision group. 15(31.2%) patients from group 1 and 12 (25%) patients achieved 6/9 vision postoperatively. 6(12.5%) patients and 8(16.7%) patients from group 1 and 2 respectively achieved 6/12 vision. 4 patients had 6/18 vision and 5 patients had 6/24 vision from group 1. Only 1 patient each in group 2 had 6/18 and 6/24 vision postoperatively. 1 patient had a vision of 6/36 in group 1. and 6/60 in group 1. 3 patients in group 1 had a vision less than 6/60 in group 1. All patients in group 2 achieved UCVA more than 6/60. 2 patients had 6/36 vision in group 2 (Table 3, Graph 2).

Table 3: Comparison of postoperative uncorrected visual acuity between straight and frown incision.

Postoperative Ucva	Group 1		Group 2	
	N	%	N	%
6/6	13	27.1%	24	50%
6/9	15	31.2%	12	25%
6/12	6	12.5%	8	16.7%
6/18.	4	8.3%	1	2.1%
6/24.	5	10.4%	1	2.1%
6/36.	1	2.1%	2	4.1%
6/60.	1	2.1%	–	–
<6/60.	3	6.3%	–	–
Total	48	100%	48	100%

UCVA – Uncorrected visual acuity
N– Number of patients
%– Percentage

Graph 2: Bar diagram showing comparison of postoperative uncorrected visual acuity between straight and frown incision.



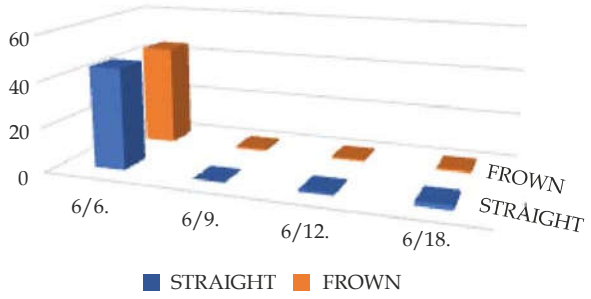
45 (93.7%) patients in group 1 and 45 (93.7%) patients in group 2 achieved a BCVA of 6/6. 1 patient had 6/12 and 2 patients had 6/18 BCVA in group 1. One patient each in group 2 achieved BCVA of 6/9, 6/12 and 6/18 (Table 4, Graph 3).

Table 4: Comparison of postoperative best corrected visual acuity between straight and frown incision.

Postoperative Bcva	Group 1		Group 2	
	N	%	N	%
6/6	45	93.7%	45	93.7%
6/9	–	–	1	2.1%
6/12	1	2.1%	1	2.1%
6/18	2	4.2%	1	2.1%
Total	48	100%	48	100%

BCVA – Best Corrected Visual Acuity
N– Number of patients
%– Percentage

Graph 3: Bar diagram showing comparison of postoperative best corrected visual acuity between straight and frown incision.



Preoperatively in group 1, 2(4.1%) patients had no astigmatism, 33(68.75%) patients had with-the-rule astigmatism (WTR), 10(20.83%) patients had against-the-rule astigmatism (ATR) and 3(6.25%) patients had oblique astigmatism. 19(39.58%) had non-significant astigmatism, 14(29.17%) had significant astigmatism and 13(27.08%) patients had highly significant astigmatism in group 1. In group 2,3(6.25%) patients had no astigmatism, 24(50%) patients had WTR astigmatism, 13(27.08%) patients had ATR and 8(16.67%) patients had oblique astigmatism. 23(47.9%) had non-significant astigmatism, 16(33.33%) had significant astigmatism and 6(12.5%) patients had highly significant astigmatism in group 2.

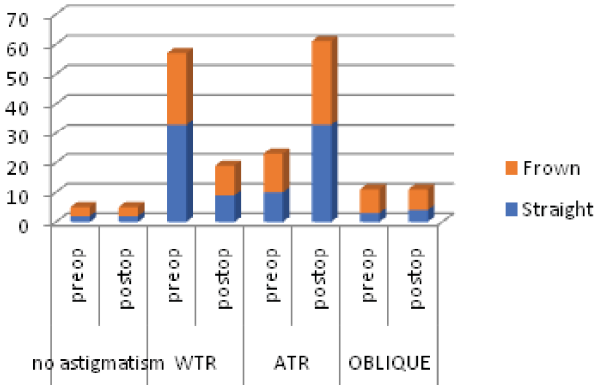
The majority of patients in both the groups had WTR astigmatism preoperatively.Among the patients with WTR astigmatism in either groups, most people had nonsignificant astigmatism (Table 5).

Table 5: Preoperative astigmatism.

Incision	No Astigmatism	WTR			ATR			Oblique			Total
		Non Sig	Sig	High Sig	Non Sig	Sig	High Sig	Non Sig	Sig	High Sig	
Straight (group 1)	2	14	12	7	5	2	3	–	–	3	48
Frown (group 2)	3	13	9	2	7	5	1	3	2	3	48
Total	5	29	21	9	12	7	4	3	2	6	96

Postoperatively in group 1, 2(4.1%) patients had no astigmatism, 9(18.75%) patients had WTR astigmatism, 33(68.75%) patients had ATR astigmatism and 4(8.3%) patients had oblique astigmatism. 15(31.25%) had non-significant astigmatism, 16(33.3%) had significant astigmatism and 15(31.25%) patients had highly significant astigmatism in group 1. In group 2, 3 patients had no astigmatism, 10(20.8%) patients had WTR astigmatism, 28(58.33%) patients had ATR astigmatism and 7(14.58%) patients had oblique astigmatism. 22(45.83%) had non-significant astigmatism, 17(35.4%) had significant astigmatism and 6(12.5%) patients had highly significant astigmatism in group 2. (Table 6).

Graph 4: Comparison of type of preoperative and postoperative astigmatism in straight and frown incision.



The majority of patients in both the groups had WTR astigmatismpreoperatively. Among the patients with WTR astigmatism in both groups, most people had nonsignificant astigmatism while highly significant WTR astigmatism was nil in both groups. In group 1 the number of patients with highly significant ATR astigmatism was more while it was less in group 2. (Table 6, Graph 4)

The mean magnitude of SIA in straight incision was 1.69 ± 0.82 D and in frown incision was 0.61 ± 0.35 D. The mean axis of SIA in straight incision was 87.88± 60.94 and in frown incision was 83.75± 62.37.

The mean difference between the SIA magnitude of straight and frown was found to be statistically significant, p=<0.001, while the mean SIA axis when compared between both the groups was not found to be statistically significant=0.744. (Table 7)

Table 8: Results of cartesian coordinates-based analysis of group 1 (straight incision)

	Mean ±SD		Centroid	Coherence (%)
	X Value	Y Value		
Preoperative Astigmatism	–0.65±1.16	0.16±0.67	0.67X83°	56
Postoperative Astigmatism	0.75±1.35	0.2±0.67	0.77X7°	59
Surgically Induced Astigmatism	1.4±0.91	0.03±0.48	1.49X1°	90

The centroid value (mean SIA vector) of preoperative astigmatism in group1 with straight incision postoperative astigmatism is 0.67x 83° with a coherence of 56% and that of group 2 is 0.77 x 7° with a coherence of 59%. The centroid of SIA for straight incision is 1.49x1° with a coherence of 90%(Table 8, graph 5).

Table 9: Results of cartesian coordinates-based analysis of group 2 (frown incision).

	Mean±SD		Centroid	Coherence (%)
	X Value	Y Value		
Preoperative Astigmatism	–0.23±1.0	0.23±0.75	0.33X67°	33
Postoperative Astigmatism	0.39±1.01	0.26±0.72	0.47X17°	45
Surgically Induced Astigmatism	0.62±0.76	0.03±0.39	0.62X2°	70

The centroid value of preoperative astigmatism in group 2 with frown incision is 0.33X67° with

Table 6: Postoperative astigmatism.

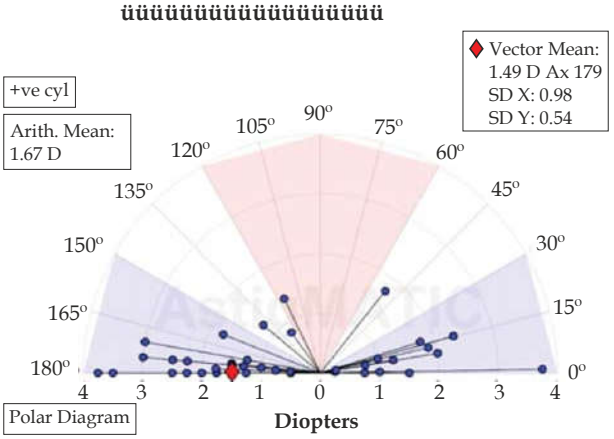
Incision	No Astigmatism	Wtr			Atr			Oblique			Total
		Non Sig	Sig	High Sig	Non Sig	Sig	High Sig	Non Sig	Sig	High Sig	
Straight (group 1)	2	5	4	–	10	11	12	–	1	3	48
Frown (group 2)	3	7	3	–	13	12	3	2	2	3	48
Total	5	12	7	–	23	23	15	2	3	6	96

Table 7: Comparison of surgically induced astigmatism between straight and frown incision.

	Group	N	Mean	Std. Deviation	Std. Error Mean	P-Value
SIA Magnitude	Straight Incision	48	1.688333	0.8180447	.1180746	<0.001
	Frown Incision	48	0.6058	0.3502	0.0505	
SIA Axis	Straight Incision	48	87.88	60.941	8.796	0.744
	Frown Incision	48	83.75	62.37	9.003	

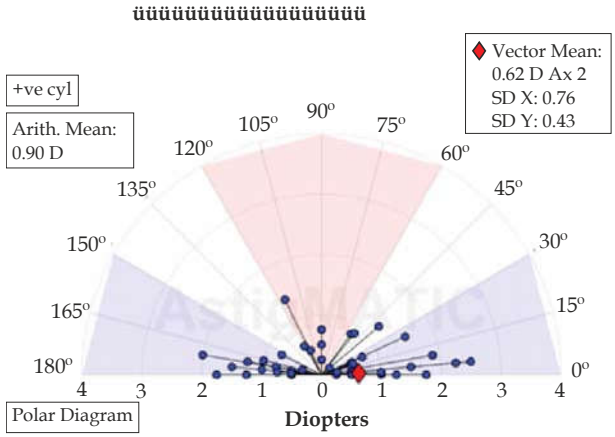
a coherence of 33% and that for postoperative astigmatism is 0.47X17° with a coherence of 45%. The centroid of SIA for frown incision is 0.62X2°with a coherence of 70% (Table 9, Graph 6).

Graph 5: Single angled polar plot showing SIA vector in straight incision (group 1).



The single angled polar plots shows clustering of coordinates around the centroid value.

Graph 6: Single angled polar plot showing SIA vector in frown incision (group 2).



Discussion

The mean age of subjects in group 1 was 64.2 years and in group 2 was 63.5 years. In Group 1 and Group 2, majority of subjects were in the age group 66 to 70 years (45.8% and 43.8% respectively). There was no significant difference in age distribution between two groups.

Group 1 consisted of 29 females (60.4%) and 19 males (39.6%). Group 2 consisted of 30 females (62.5%) and 18 males (37.5%). There was no significant difference in gender distribution between two groups.

In Group 1, 56.2% underwent surgery for right eye and 43.8% underwent surgery for the left eye. In Group 2, 58.3% underwent surgery for right eye and 41.7% underwent surgery for the left eye. The majority of patients in either group underwent operation for the right eye. There was no statistical significance in the eye operated between both the groups.

All patients were followed up for a period of 6 weeks postoperatively. The UCVA of group 2 was better when compared to group 1. 13(27.1%) patients achieved postoperative emmetropia in straight incision group while 24 (50%) patients achieved postoperative emmetropia in frown incision group. All patients achieved a BCVA of ≥ 6/18. the visual outcome following frown incision was observed to be better than that of straight incision, but it was not found to be significant.

The mean magnitude of preoperative astigmatism in straight incision was 1.26±0.92 D and in frown incision was 0.98±0.83D. There was no significant statistical difference in both the groups.

Study by Jauhari N, Chopra D et al. gave a mean SIA of -1.08±0.67D and –0.96± 0.71 for straight and frown incisions respectively.[5] Comparatively, our study gave a lesser SIA with frown incision and a larger SIA with straight incision. The arithmetic mean of SIA in our study was 1.69±0.82D for straight incision while it was 0.61±0.35D for frown incision. The difference in the mean SIA between both the groups were found to be statistically significant, p=<0.001

SIA in our study was calculated using SIA calculator which is an analysis based on cartesian coordinates. It allows the analysis of a large number of data accurately. SIA calculator considers not only the magnitude of astigmatism but also the axes of astigmatism. The arithmetic mean may not give an accurate prediction of the actual average as it ignores the axes of astigmatism. Centroid is the mean SIA vector and is often a better predictor of the mean of an astigmatic vector.

In our study, the centroid values of preoperative and postoperative astigmatism in group 1 with straight incision was 0.67 x 83° and 0.77 x 7° respectively. The centroid values of preoperative and postoperative astigmatism in group 2 with frown incision was 0.33 x 67° and 0.47 x 17° respectively.

Arthur E et al., studied the postoperative corneal astigmatism and the SIA following superior approach MSICS in patients with preoperative ATR astigmatism. He analysed the SIA using

Cartesian coordinates-based analysis. Centroid values were found to be 1.42 × 179°, 2.48 × 0°, 1.07 × 1° for preoperative astigmatism, postoperative astigmatism and SIA respectively.[10]

Coherence is an indicator of tightly clustered data set. When the coherence value is low, it means that the SIA vectors are more scattered and they cancel each other out. Therefore, when the coherence value is high, the centroid is more representative of the group as a whole and it also shows that the predictability of the SIA for the particular incision is high for the surgeon.[11]

The centroid of SIA was lesser in frown incision being 0.67 x 2° with 70% coherence when compared to straight incision which was 1.4x1° it was also seen that the coherence of the SIA in straight incision was 90%, showing that the SIA was a tightly clustered set of points and therefore more predictable. However, this might vary between surgeons. A study by Gokhale NS, Sawhney S showed that the mean SIA for frown incision with superior site to be 1.28 x 29°.

The highest value of SIA obtained for straight incision was 3.75 x 90° and for frown incision was 1.88 x 10° and the lowest values were 0.25 x 175° and 0.03 x 44° for straight and frown incisions respectively.

The majority of patients in both the groups had with-the-rule astigmatism preoperatively.

Majority of patients in both the groups had ATR astigmatism postoperatively. Studies conducted previously has reported ATR shift in astigmatism postoperatively. Our study is consistent with this finding.

Among the patients with WTR astigmatism in both groups, most people had nonsignificant astigmatism while highly significant WTR astigmatism was nil in both groups. In group 1 the number of patients with highly significant ATR astigmatism was more while it was less in group 2.

Any incision lying in the incisional funnel is astigmatically neutral. Frown incision lie entirely within this tunnel. This might be the cause of less astigmatism compared to straight incision in our study.

Conclusion

The visual outcome of frown incision group was slightly better than the visual outcome in straight incision group. The difference in visual acuity was not found to be statistically significant.

The SIA of straight incision was more than that of frown incision. The mean magnitude of SIA was statistically significant but mean axis of SIA was not found to significant.

The use of both straight and frown incision in superior site SICS led to ATR shift postoperatively.

All patients who participated in this study achieved a BCVA of ≥ 6/18.

Multicentric randomized controlled studies with similar objectives may be required for more accurate analysis.

References

1. Bourne RRA, Flaxman SR, Braithwaite T, Cicinelli MV, Das A, Jonas JB, et al. Magnitude, tempora Vl trends, and projections of the global prevalence of blindness and distance and near vision impairment: a systematic review and meta-analysis. Lancet Glob Health 2017;5:888–97.
2. Archana S, Khurana A, Chawla U. A comparative study of sclero-corneal and clear corneal tunnel incision in manual small-incision cataract surgery. Nepal J Ophthalmol 1970;3:19–22.
3. Sachdev M, Sethi H, Gadia R, Agarwal A, Dada T, editors. Techniques of cataract surgery. 1st ed. New Delhi: Jaypee brothers medical publishers (P) LTD; 2007.
4. Amedo AO, Amoah K, Koomson NY, Kumah DB, Osae EA. Assessment of corneal astigmatism following frown and straight incision forms in sutureless manual small incision cataract surgery. Clin Optom 2016;8:47–52.
5. Jauhari N, Chopra D, Chaurasia RK, Agarwal A. Comparison of surgically induced astigmatism in various incisions in manual small incision cataract surgery. Int J Ophthalmol 2014;7:1001–4.
6. Holmstrom G, el Azazi M, Kugelberg U. Ophthalmological follow up of preterm infants: a population based, prospective study of visual acuity and strabismus. Br J Ophthalmol 1999;83:143–50.
7. Aggarwal A, Sawhney S. About Insight Eye Clinic [Internet]. [cited 2019 Nov 19]. Available from: https://www.insighteyeclinic.in/SIA_calculator.php.
8. Astig MATIC Software and trial datasets for BMC Ophthalmology peer-review [Internet]. [cited 2019 Nov 19]. Available from: https://www.lasikmd.com/media/astigmatic/index.php.
9. Gauvin M, Wallerstein A. AstigMATIC: an automatic tool for standard astigmatism vector analysis. BMC Ophthalmol 2018;18:255.
10. Arthur E, Sadik AA, Kumah DB, Osae EA, Mireku

FA, Asiedu FY, et al. Postoperative Corneal and Surgically Induced Astigmatism following Superior Approach Manual Small Incision Cataract Surgery in Patients with Preoperative Against-the-Rule Astigmatism. J Ophthalmol 2016;2016:1–7.

11. Sawhney S, Aggarwal A. SIA Analysis: A step by step approach. 1st ed. Saurabh Sawhney; 2015. 84 p.
12. Gokhale N, Sawhney S. Reduction in astigmatism in manual small incision cataract surgery through change of incision site. Indian J Ophthalmol 2005;53:201.