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Original Research Article

Study of comparison of surgically induced astigmatism after small incision cataract surgery and phacoemulsification surgery

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ABSTRACT

Objectives: To compare surgically induced astigmatism after manual small incision cataract surgery and phacoemulsification surgery. 2) To know the prevalence of pre-existing astigmatism, it's magnitude and type and patients with cataract. 3) To calculate the average astigmatism induced after manual small incision cataract surgery and also to know the type of astigmatism and change in it in first month of surgery. 4) To calculate the average astigmatism induced after phacoemulsification surgery and also to know the type of astigmatism and change in its first month of surgery. 5) To study changes in astigmatism and its effect on vision after cataract surgery. 6) To compare astigmatism induced by straight and frown incision after operation.

Materials and Methods: The study was carried out in Department of Ophthalmology, P.D.U government Medical College, Rajkot under guidance of operating surgeons and patients operated in the duration of 24 months from September 2020 to October 2022.Informed consent was obtained from all the patients undergoing study. It was a prospective study and all the patients were randomly selected over the above mentioned period that had cataract with normal anterior and posterior segments. To have a more homogeneous study population all the patients underwent a similar Preoperative, Intra operative, Postoperative Surgical protocols. All eyes were operated under peribulbar anaesthesia with 2% lignocaine+bupivacain+hyalronidase. Superior sclero corneal pocket tunnel with external incision of frown configuration in manual SICS and straight incision in phacoemulsification was made. All the cases with 3.2 mm of incision in phacoemulsification and 6.5 mm incision in manual SICS were taken. Surgically induced astigmatism was then calculated by the subtraction method and vector analysis.

Result: Average SIA in SICS was 1.32 SD and in Phacoemulsification was 0.60 SD which means that larger incision size increases SIA. SIA was maximum on first post-operative day and it regressed with time as noted on first post-operative month in both the groups. It decreased from 1.66 D on first postoperative day to 1.32 D on first postoperative month in SICS Patients and from 0.63 D to 0.60 D in Phacoemulsification patient.

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1. Introduction

Cataract is the most common cause of blindness in world. In India, it is responsible for 62.60% cases of blindness.[1] Thus, by the current Indian definition of blindness there are over 12 million people blind due to cataract in India.[2] Our current knowledge of the disease indicates that there is no effective medicinal treatment the only curative treatment for cataract being surgery.[3] Although cataract surgery has been performed since ancient times, the lasthalf century has seen remarkable refinements of the procedure. The moderncataract surgery aims at earliest visual rehabilitation

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in a minimal invasivemanner. Today cataract surgery is also being considered a form of refractivesurgery offering improvements in both best corrected and uncorrected visualacuity. Corneal astigmatism or surgically induced astigmatism has been a by¯product of cataract surgery since the first limbal incision was made. Surgicallyinduced astigmatism is a big deterrent to ophthalmologists aim of making hispatients emmetropic because it is an integral part of the postoperativerefractive error.Currently majority of cataract surgeries are either small incision cataractsurgery or phacoemulsification. Phacoemulsification has become the biggestsurgical achievement of the present decade; it is still not practised by amajority of surgeons in developing countries and not feasible for masssurgeries as practised in India.Thus, it is important to study the post operative astigmatism in both types ofsurgeries so that we can modify the causative factors. That will help inobtaining a more rapid visual rehabilitation, greater patient satisfaction andbetter optical results along with quality of vision. In fact, today the emphasis isnot only on eliminating or minimising surgically induced astigmatism but alsoneutralising any pre-existing astigmatism.Previous many studies have compared SIA in manual small incision cataractsurgery with temporal versus superior incision. Similarly, there are studiesabout SIA comparing incision sites in phacoemulsification. Also, comparingvarious sizes of incision and induced astigmatism. This study is designed to study to compare astigmatism (SIA) induced after manual small incision cataract surgery and phacoemulsification at tertiary health care centre, Rajkot, Gujarat.

2. Materials and Methods

The study was carried out in Department of Ophthalmology at Tertiary health centre Rajkot with due knowledge and permission of operating surgeons and patients operated in the duration of 24 months from September 2020 to October 2022.

Informed consent was obtained from all the patients undergoing study. It was a prospective study and all the patients were randomly selected over the above-mentioned period that had cataract with normal anterior and posterior segments. To have a more homogeneous study population all the patients underwent a similar Preoperative, Intra operative, Postoperative Surgical protocols.

All eyes were operated under peribulbar anaesthesia with 2% lignocaine+bupivacain+hyalronidase. A Superior sclero corneal pocket tunnel with external incision of frown and straight configuration in manual SICS and straight incision in phacoemulsification was made. In all the cases incision of size 3.2 mm was used in phacoemulsification and incision of size 6.5 mm was used in manual SICS.

Patients with any other ocular disease or any prior surgery of eye other than cataract, patients in whom any intra operative complication occurred, patients with any wound related problems and patients in whom sutures were taken on wound postoperatively were excluded from the study.

Through exclusion criteria, 500 patients were selected which were grouped into:

Group 1 of 250 patients cataract surgery. Who underwent manual small incision cataract surgery. Group II of 250 patients who underwent phacoemulsification surgery.

2.1. Procedure

Preoperative assessment of the patient was done thoroughly which included history taking, keratometry on automated refractokeratometer, IOL power calculation, visual acuity measurement, anterior and posterior segment examination and tonometry.

Post-operative keratometry readings (on automated keratometer) and visual acuity were taken at first postoperative day, first postoperative week and first postoperative month. Subjective refraction was done at the end of one month to know the best corrected visual acuity. Surgically induced astigmatism was then calculated by vector analysis method and subtraction method.

2.2. Subtraction method

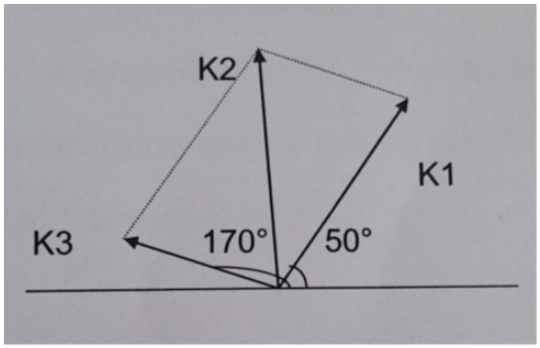
It is used to calculate the difference if the axes are 90 degrees apart. Example, if preoperative keratometry reveals +1.00 D x 90 and the postoperative finding is +1.00 D x 180°, there has been a net change of +2.00 D x180° induced by the surgery. This is simple subtraction method. However, this is not a simple task if the axes are obliquely related to each other.

2.3. Vector analysis method

Here we find the sum of oblique cylinders in which the cylinder is represented on a graph by vector. The vectors representing the cylindric powers are directed at angles twice the actual angles of orientation before the eye and the final axis is divided by two.e.g. K1 (preop corneal astigmatism) = 2.00 x 25°.

K3 (postop cornel astigmatism) =1.50 x 85.

K1 is represented on a graph as a line 2 unit long at 50-degree meridian K3 is plotted as a line 1.50 unit long at the 170-degree meridian. The parallelogram is completed. Line K2 (resultant) is 1,75 units long at 98 degrees. Thus, SIA is 1.75 D x 49. We can modify this technique by construction of a triangle also.



Rectangular coordinates. Any point may be represented on a graph by rectangular and polar coordinates. The rectangular coordinates of K2 are thus calculated by subtracting the x and y coordinates from K1 from those of K3

Thus K2=K3-K1 = (xK3-xK1, yK3-yK1)

Other methods for calculating SIA are: -

1. Law of sines and cosines
2. Vector decomposition
3. Cravys vertical vectors
4. Naesers Polar Values
5. Algebraic method
6. The double angle vector diagram

Online calculators: Two popular online SIA calculators are available at http://doctor-hill.com/physicians/download.htm (East Valley Ophthalmology, Arizona) and (http://www.insighteyeclinic.in/SIA_calculator.php. Both of these free online calculators use the method of SIA calculation described by Holladay et al.

3. Results

Table 1: Sex distribution

Sex	Male	Female
Group 1	116	134
Group 2	141	109
Percentage	51.4%	48.6%

Table 1 thus shows that in this study, 51.4% patients were males and 48.6% were females. Among 500 cases, 57.2% Right eye and 42.8% Left eye were operated.

Table 2: Age distribution of patients

Age	Group 1	Group 2	Percentage
<=50	39	15	10.8%
51-60	89	89	35.6%
61-70	72	92	32.8%
71-80	37	50	17.4%
>80	13	04	3.4%

Table 2 show that maximum patients i.e., 35.6% were in age group 51 to 60 years. Least number of patients were in age group above 80 years i.e., 3.4%.

Table 3: Distribution of pre- existing astigmatism in diopters

Pre-existing astigmatism	Group 1	Group 2	Percentage
Low (<1D)	129	130	51.8%
Moderate (1-2D)	106	93	39.8%
High (>2D)	15	27	8.4%

Table 3 shows that in maximum patients (51.8%) there was low pre operative astigmatism (<1D). The range of astigmatism was 0 to 4D in group 1 and the range of astigmatism was 0 to 2.5D in group 2. The average pre operative astigmatism in group 1 is 1.1 in group 1 and in group 2 is 0.84.

Table 4: Distribution of pre-existing astigmatism according to its type

Pre-existing astigmatism	Group 1	Group 2	Percentage
WTR	183	185	73.6%
ATR	67	65	26.4%

Cases which had steep axis between 45-135 degrees were considered in WTR group and those between 0-44 or 136-180 were considered in ATR group. Table 4 shows that 73.6% cases had WTR and 26.4% cases had ATR astigmatism with nearly equal distribution in both study groups.

Table 5: Distribution of average post operative astigmatism in both the groups in diopters:

Average Post operative astigmatism	Group 1	Group 2
1^{st} Postoperative Day	1.75	1.05
1^{st} Postoperative week	1.22	1.02
1^{st} Postoperative Month	1.04	0.90

Table 5 shows that at the end of first postoperative month average post-operative astigmatism in group 1 was 1.04 and in group 2 was 0.90. In both groups average post-operative astigmatism was maximum on first post-operative day. This data when analyzed by students T- Test gives p value less than 0.01 implying that difference in both groups was significant.

Table 6: Distribution of average SIA in both the groups in diopters

Average SIA	Group 1	Group 2
1st Postoperative Day	1.66	0.63
1st Postoperative week	1.48	0.61
1st Postoperative Month	1.32	0.60

Table 6 shows that at the end of first postoperative month average SIA in group 1 was 1.32 and in group 2 was 0.60. In both groups average SIA was maximum on first post-operative day. This data when analyzed by students T- Test gives p value less than 0.05 implying that difference in both groups was significant.

Table 7: Distribution of SIA according to type of astigmatism

SIA	Group 1		Group 2	
	WTR	ATR	WTR	ATR
1^{st} Postoperative Day	48	202	185	65
1^{st} Postoperative Week	35	215	181	69
1^{st} Postoperative Month	36	214	176	74

Table 7 shows that group 1 cases had more ATR astigmatism at end of 1^{st} post operative month (80%) as compared to group 2 cases whereas group 2 cases had more WTR astigmatism (67%).

Table 8: Distribution of post- operative astigmatism in group 1 patients in diopters

Post-operative astigmatism	0-0.5	0.51-1	1.01-1.5	1.51-2	2.01-2.5	>2.5
1^{st} post operative day	20	63	66	65	21	15
1^{st} post operative week	27	83	71	47	9	13
1^{st} post operative month	49	77	82	30	6	6

Table 8 shows that maximum cases with post-operative astigmatism in group 1 were in sub group 1.01-1.5 dioptres at the end of 1^{st} post-operative month.

Table 9: Distribution of post-operative astigmatism in group 2 patients indiopters

Post-operative astigmatism	0-0.5	0.51-1	1.01-1.5	1.51-2	2.01-2.5
1st post operative day	22	62	61	70	21
1st post operative week	51	91	47	39	9
1st post operative month	68	65	58	30	13

Table 9 shows that maximum cases with post-operative astigmatism were in sub group 0-0.5 diopters in group 2 patients at the end of 1^{st} post-operative month.

Table 10 shows that maximum SIA were in sub group 1.01-1.5 dioptres in group 1 patients at the end of 1^{st} post operative month.

Table 11 shows that maximum SIA were in sub group 0.51-1 dioptres in group 2 patients at the end of 1^{st} post-operative month.

Table 12 shows that in group 1 there were more cases of ATR type of SIA with average SIA of 1.1 Dioptres and in group 2 there were more cases of WTR type of SIA with average of 1.01 Dioptres at end of first post-operative month.

Table 13 shows in group 1 patients, SIA was more after straight incision as compared to the frown incision after one month 1^{st} post operative period.

4. Discussion

Average SIA in SICS in present study was 1.32 and in other studies by Hazra S, et al[4] it was 1.00, D Singh et al[5] it was 1.12, V Sharma et al[6] it was 1.36, Bhaskar Reddy et al[7] it was 1.92. Average SIA in phacoemulsification in present study was 0.60 and in other studies like Hazra S, et al. it was 0.87, D Singh et al. it was 0.77, George et al[8] it was 0.77, Lhyne et al[9] it was 0.61 and Bhaskar Reddy et al. it was 1.23.

On comparing SIA in SICS and phacoemulsification in present study it was found SIA was less in Phacoemulsification. SIA in SICS and phacoemulsification in present study was 1.32 and 0.60 respectively. In other studies, like by George et al. (SIA in SICS and Phacoemulsification was 1.17 and 0.77 respectively) and by Bhaskar Reddy et al (SIA in SICS and Phacoemulsification was 1.92 and 1.23 respectively) results were same as our study.

Type of SIA in SICS in present study showed 20% patient had WTR, while 80% patient had ATR which was similar to results in other studies like by R.C. Nagpal et alwhere 58.3% patient had WTR while 41.7% patient had ATR, and in study by D Singh et al, where 32.5% patient had WTR while 54.5% patient had ATR. Greater percentage of WTR in SICS can be attributed to the superior scleral incision (irrespective of configuration of incision) causing the flattening of the axis of incision i.e vertical axis and relative steeping of the horizontal axis.

In present study, on comparing incision configuration it was found superior scleral frown incision showed less SIA (SIA in frown incision 1.0) in comparison to superior scleral straight incision in SICS. In other studies, like by Bhaskar et al, SIA was 1.57 and 1.92 in superior scleral frown and superior scleral straight incision respectively and by D Singh et al SIA in superior scleral straight incision was 1.22 and 1.1 in superior frown scleral incision. Irrespective of the configuration of incision, SIA in SICS was higher than phacoemulsification.

Table 10: Distribution of SIA in group 1 patients in diopters

SIA	0-0.5	0.51-1	1.01-1.5	1.51-2	2.01-2.5	>2.5
1^{st} post operative day	4	28	65	109	27	13
1^{st} post operative week	2	59	81	89	10	9
1^{st} post operative month	9	50	93	74	6	18

Table 11: Distribution of SIA in group 2 patients in dioptres

SIA	0-0.5	0.51-1	1.01-1.5	1.51-2	2.01-2.5	>2.5
1st post operative day	92	113	33	12	0	0
1st post operative week	110	111	29	0	0	0
1st post operative month	111	122	17	0	0	0

Table 12: Distribution of SIA at first post-operative month according to type and average in both groups

SIA	WTR		ATR	
	No. of cases	Average in dioptres	No. of cases	Average in dioptres
Group 1	35	1.26	215	1.1
Group 2	172	1.01	78	0.9

Table 13: Distribution of post operative astigmatism according to type of incision in group 1 patients

SIA	Straight incision	Frown incision
1^{st} post operative day	1.93	1.32
1^{st} post operative week	1.63	1.18
1^{st} post operative month	1.5	1

On comparing size of incision, it was found SIA was higher in incision size of 6-6.5mm in SICS in comparison to 3.2mm to 3.8mm incision in phacoemulsification. Similar results were seen in study by George et al (SIA in SICS was 1.17 while in phacoemulsification it was 0.77), by Dr R.C Nagpal et al, and by D Singh et al.

SIA decreased from 1.66 D on first postoperative day to 1.32 D on first postoperative month in group I and from 0.63 D to 0.60 D in group 2. SIA was maximum on first post-operative day and it regressed with time as noted on first post-operative month in both the groups.

Post-operative astigmatism was ATR type in majority of cases Group 1 (SICS) as there was a flattening in the axis of the incision in surgeries (superior scleral site in study cases). In group II there was not much shift of astigmatic axis to ATR type which means that smaller incisions do not cause axis shift significantly. In majority of patients, average post-operative residual astigmatism was 1.04 D in group I and 0.90 D in Group II at the end of first postoperative month. All cases with tunnel complications were found to have higher astigmatism (these cases were not included in study to avoid error). If we extrapolate the regression seen in this study in post operative astigmatism in SICS, then it will be very low in amount at the end of one year.

5. Conclusion

Majority of cases (51.8%) had low (<1 D) pre-existing astigmatism. Only 8.4% cases had high pre-existing astigmatism (>2 D). Majority of cases (68.5%) had pre-existing astigmatism of WTR type.

Average SIA in group I (SICS) was 1.32 SD and in group II (Phacoemulsification) was 0.60 SD which was due to larger incision size in SICS in comparison to phacoemulsification.

Average post-operative residual astigmatism was 1.04 D in group I and 0.90 D in Group II at the end of first postoperative month. Post-operative astigmatism was ATR type in majority of cases Group 1 (SICS) and in group II there was not much shift of astigmatic axis to ATR type.

Superior scleral frown incision showed less SIA (SIA in frown incision 1.0) in comparison to superior scleral straight incision in SICS.

Visual outcome in both SICS and Phacoemulsification was same. Thus, SICS is a good, safe, effective and economical alternative of phacoemulsification surgery.

6. Abbrevations

SIA: Surgical induced astigmatism; WTR: With the rule astigmatism; ATR: Against the rule astigmatism; SICS-Small incision cataract surgery.

7. Ethical Approval

The study received ethical clearance from institutional ethical committee.

8. Source of Funding

None.

9. Conflict of Interest

The authors declare that they have no conflict of interest.

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