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Original Research Article

Comparison of Surgically Induced Astigmatism in Manual Small Incision Cataract Surgery Following Straight Versus Frown Incision

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ABSTRACT

High astigmatism is an important cause of poor uncorrected visual acuity after cataract surgery. Surgically Induced Astigmatism (SIA) plays an important role in final post operative visual acuity. The aim of the study is to compare the astigmatism induced by a straight and frown incision in manual SICS (MSICS) in patients with Immature Pre-senile and Senile Cataract.

This is a randomized, prospective study conducted at the Department of Ophthalmology, ESIPGIMSR, Basaidarapur, New Delhi. The patients undergoing manual SICS were selected for the study strictly adhering to the inclusion and exclusion criteria. The patients were randomly divided into two groups, that is Group A, 50 patients (patients who underwent MSICS with frown incision) and Group B, 50 patients (patients who underwent MSICS with straight incision).

In Group A (frown incision group), the mean SIA was 0.83±0.53 D and in Group B (straight incision group), the mean SIA was 1.37±0.92 D post-operatively after 90 days. The comparison between the mean of the two groups using 'unpaired t test' was statistically significant ($p<0.05$) indicating that group B had more SIA.

The relative increase in astigmatism in Group B with straight incision is due to the proximity of the incision to the optical centre resulting into comparatively increased corneal changes. In Group A, lesser amount of SIA was due to the location of the incision away from the optical axis and flattening at the incision site was less.

The UCVA was better in the frown incision as compared to the straight incision group.

In conclusion, frown incision is evidently better than straight incision in minimizing surgically induced astigmatism.

Keywords: Surgically Induced Astigmatism, Manual Small Incision Cataract Surgery, Straight Incision, Frown Incision

INTRODUCTION

Astigmatism is that condition of refraction wherein a point focus of light, cannot be formed upon the retina owing to unequal refraction of incident light by dioptric system of eye in different meridians, but form focal lines. [1]

Prevalence of astigmatism and changes with age

In the first months of life, infants show a high prevalence of high (6D average) ATR astigmatism (corneal). The steepest most astigmatic corneas occur in newborns with the lowest birth weight and lowest post conceptual age. As infants grow, emmetropisation of astigmatism occurs. Astigmatism shifts to low levels of WTR after four years of age and pressure from

eyelids on the cornea over time has been suggested as a cause. Children typically display WTR astigmatism.

Young adults typically display small degrees of WTR astigmatism and in older adults shift occurs and ATR astigmatism becomes more prevalent.

Research has estimated that 15-29% of patients with cataract have more than 1.5 D of pre-existing astigmatism. [2] In a general cataract population, approximately 10% of patients have astigmatism with greater than 2 D of cylinder, 20% have between 1 and 2 D, and 70% have less than 1D. [3-6]

Effects of astigmatism on vision

Astigmatism induces distortion of image. The retinal image is distorted because of a differential magnification in the two principal meridians. There is 0.3% image distortion per diopter of astigmatism. [7]

In WTR astigmatism, the power of weaker principal meridian produces a vertical line focus. In printed matter the vertical strokes of the letter are more important for recognition for example b,d,h, also there is less space between letters than between lines.

Hence it is useful to have a better focus in vertical meridian as is there in myopic WTR astigmatism, resulting in better Snellen visual acuity.

Another benefit of WTR astigmatism is that less cylinder is required in spectacle correction than ATR astigmatism of same magnitude. In corrected, astigmatic eye, retinal image distortion arises due to unequal spectacle magnification in the two principal meridian, representing 1.6% distortion per dioptre cylinder correction.

More over spectacle cylinder will be less than the ocular astigmatism when the spherical equivalent is positive and greater than the ocular astigmatism when spherical equivalent is negative. So in general myopic ATR astigmatism will result in proportionally larger spectacle correction, which will produce more distortion. A certain degree of myopic astigmatism is useful as it may produce a situation of pseudo-accommodation in a pseudophakic patient. [8]

Uncorrected astigmatism causes blurred image, glare, monocular diplopia. Even with appropriate spectacle correction the meridional magnification may create distortion. The patients having preoperative astigmatism may experience difficulty adapting to axis shift induced by surgery. Any of these effects may create not only dissatisfaction with visual outcome, but also discomfort with an otherwise uneventful surgery.

Manual Small Incision Cataract Surgery [9]

Manual SICS is a self sealing cataract surgery due to the sclera-corneal tunnel construction. Lower cost of instrumentation and disposables in manual SICS is an added advantage. [10,11] It is also better suited for advanced and mature cataracts seen in developing countries. [12] In this incision the internal incision in the anterior chamber is remote from the external scleral incision and the two are connected together by a sclera corneal tunnel. When the internal pressure of the eye is re-established, the high intraocular pressure (IOP), compared to the lower atmospheric pressure causes the tunnel to collapse and self seal.

The various incisions which are used in manual SICS vary according to their site, dimensions, design and architecture. The site of incision can be superior or superotemporal or temporal. The dimensions of the incision can vary from a 3.5mm to a 6mm or longer in case of rigid IOLs. Other factors which affect incision size are;

Type of intraocular lens – incision size is small for foldable IOLs and large for rigid IOLs. (PMMA).

Type of cataract – incision size will be larger for hard brown cataract

Technique of nucleus delivery – small incision size is enough if nucleus is divided

in anterior chamber and removed in two pieces.
Skill of the surgeon.
Design of the wound – in the wound design, the internal incision is always larger than the external, giving the shape of a funnel to the wound. The inner lip of the wound normally has a width of 8 to 9 mm.

The various shapes of incisions in use for manual SICS are;
Horizontal incision or straight incision
Frown shaped incision
Chevron incision

Smile incision
Horizontal incision with straight backwards extension
Horizontal incision with backward extensions perpendicular to the limbus (Blumenthal technique)

Aims and Objectives
- To compare the surgically induced corneal astigmatism in patients undergoing manual small incision cataract surgery by straight and frown incisions.
- To assess whether the difference by the two techniques is statistically significant.

MATERIALS AND METHODS
Study Design: 1 year, prospective study.
Sample Size: 100 (50 patients in each group).
Group A: MSICS (Frown Incision)
Group B: MSICS (Straight Incision)

Source of Data: Patients undergoing manual SICS at the Ophthalmology Department of ESI PGIMSR, Basaidarapur, New Delhi.

Inclusion Criteria
- Patients of the age group between 40-70 years.
- Patients of uncomplicated immature senile cataract with cortical cataracts and grade 3 or less nuclear sclerosis
- Patients who have completed all the post operative visits with the necessary investigations during the 3 months follow up period.

Exclusion Criteria
- Patients with previous history of ocular trauma.
- Patients with complicated cataract, congenital cataract.
- Patients having immature cataract associated with other ocular diseases.
- Patients with intra-operative and post-operative complications.
- Patients with pre-op irregular astigmatism.
- Patients with associated glaucoma, corneal scarring or degeneration, uveitis, previous intra-ocular surgeries.
- Patient with against the rule astigmatism
- Patient with grade 4 Nuclear sclerosis

Methods
Pre-operative evaluation included Name, Age, Sex, Visual acuity, Anterior Segment examination, IOP using Schiotz indentation tonometer, Fundus examination using 90 D lens with slit lamp biomicroscopy.
Corneal astigmatism was measured by keratometer (Bausch & Lomb): K_H(Horizontal), K_V(Vertical) and axis.
Eyes were randomly (simple randomization) assigned to either of the two groups.

Operative Procedure
A sample size of 100 eyes will be taken. They will be subdivided randomly into two groups of 50 eyes each. The inclusion criteria will be patients with keratometric astigmatism of 1.5 D or less, good fixation and cataract upto grade 3 nuclear sclerosis. The higher grades of nuclear sclerosis cases will be excluded to keep the uniformity in size and architecture of the incision. All surgeries will be done under peribulbar anaesthesia. Manual SICS with nucleus delivery using irrigating vectis technique will be used. The incision site will be superior in both the groups. A 6.0 mm, three planer scleral incision, 1.5 mm from the

limbus will be made with a 15 number Bard Parker blade. The incision will be given in straight line at the sclera , centre point of incision being 1.5 mm behind the superior most part of the cornea at 90˚(12 o' clock) position, for the straight incision (Group B) and in a frown pattern at the sclera, 6.0 mm in length, the centre point of incision being 1.5 mm from limbus (Group A). A funnel shaped scleracorneal pocket incision will be created with a crescent knife. One side port will be made 90^{o} to the right side of the scleral tunnel with a side port knife. Anterior chamber will be filled with Viscoelastic solution (Hydroxy Propyl Methyl Cellulose 2%), and capsulorrhexis performed with cystitome made from 26 gauge needle. With a 3.2 mm angled keratome, the anterior chamber will be entered 1.5 mm into the clear cornea to create a self sealing corneal valve. The internal incision will be enlarged sideways to 8 mm. Hydrodissection and delineation will be performed with Balanced Salt Solution (BSS). Hydro-dissection will be continued until the upper pole of the nucleus will prolapse out of the capsular bag. Through the scleral tunnel, irrigating wire vectis will be passed under the nucleus in the capsular bag, and the nucleus will be delivered directly by pulling the vectis out slightly depressing the scleral side of the incision. The cortical matter will be aspirated with Simcoe two way irrigation and aspiration cannula. A single piece intraocular lens of 6 mm optic size and 12.5 mm total size will be implanted into the capsular bag. Patients will be examined on days 1, 7, 45 and 90. Prednisolone 1% eye drop was administered hourly in the first postoperative week, six times a day in the next week and gradually tapered every week over six weeks. Moxifloxacin eye drops 0.3% was administered four times a day for the first ten days and then discontinued.

Keratometry readings were recorded on each visit. The patients were examined on postoperative day 1, after 1 week, 1 1⁄2 month and 3 months. Keratometry examinations were recorded. Surgically Induced astigmatism was calculated using Surgically Induced Astigmatism (SIA) Calculator version 1.0, a free software program. Preoperative and postoperative (day 90) keratometric readings was used for final analysis. Surgically Induced Astigmatism (SIA) will be calculated using a computer program (software) called 'SIA Calculator 1.0' for a given set of pre and postoperative keratometric data. This Surgically Induced Astigmatism Calculator (SIA Calculator) has been designed to calculate, by means of vector analysis, the amount of surgically induced astigmatism created during the cataract surgical procedure.

Surgically Induced Astigmatism (SIA) was calculated using a computer program (software) called 'SIA Calculator 1.0' for a given set of pre- and post-operative keratometric data. This Surgically Induced Astigmatism Calculator (SIA Calculator) has been designed to calculate, by means of vector analysis, the amount of surgically induced astigmatism created during the cataract surgical procedure.

Statistical Analysis

The data was analysed using SPSS Statistics software (version 20). Statistical tests like t test and repeated measures ANOVA test were used for data analysis. P-value of <0.05 was considered to be statistically significant.

OBSERVATION AND RESULTS

The present study was conducted on 100 patients who underwent Manual Small Incision Cataract Surgery at the Department of Ophthalmology, ESIPGIMSR, Basaidarapur, New Delhi during the study period. The patients were divided into 2 groups, that is Group A (Patients who underwent MSICS with frown incision) and Group B (Patients who underwent MSICS with straight incision). Mean age of patients was 60.86±7.09 years in group A and 58.46±6.60 Years in group B. The data was tabulated as below.

Table No 1: Age distribution

Age (Years)	Group A		Group B	
	No.	Percentage	No.	Percentage
45 – 50	4	8	10	20
51 – 60	15	30	23	46
61 – 70	31	62	17	34
Total	50	100	50	100

Table 2: Gender distribution

Gender	Group A		Group B	
	No.	Percentage	No.	Percentage
Male	21	42	25	50
Female	29	58	25	50
Total	50	100	50	100

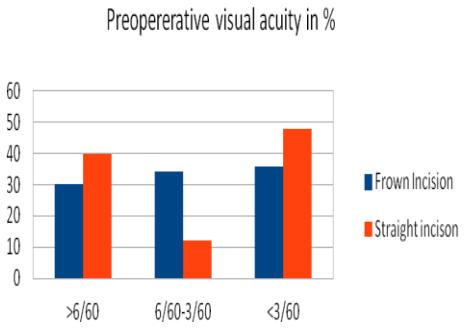

Table 3: Preoperative visual acuity

Visual acuity	Group A		Group B	
	No.	Percentage	No.	Percentage
>6/60	15	30	20	40
6/60 to 3/60	17	34	6	12
<3/60	18	36	24	48
Total	50	100	50	100

In group A 42% of patients were male and 58% were female with male:female ratio of 0.72:1` . In group B 50% were male and 50% were female with male:female ratio of 1:1.

In group A, majority of the patients (36%) were in the range of <3/60 followed by 34% in range of 6/60 to 3/60. In group B, majority (48%) had preoperative visual acuity in the range of <3/60, followed by 40% in the range of more than 6/60.

Table 4: Distribution of subjects according to post-operative visual acuity (VA) findings in Group 1 and 2 on various follow up visits.

VA (LogMAR)	Day 1		After 7 days		After 45 days		After 90 days	
	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2
6/60 to 6/36	6(12%)	20(40%)	1(2%)	7(14%)	0	2(4%)	0	0
6/24 to 6/18	23(46%)	21(42%)	15(30%)	21(42%)	4(8%)	11(22%)	3(6%)	8(16%)
6/12 to 6/6	21(42%)	8(16%)	33(66%)	22(44%)	37(74%)	31(62%)	48(96%)	42(84%)
Mean±SD	.42±.18	.66±.30	.31±.15	.45±.20	.22±.12	.32±.18	.19±.13	.24±.14
Significance	p=0.00*		p=0.00*		p=0.003*		p=0.067**	

*Significant; **Non-significant

In Group A, on Day1, 46 % of the patients had 6/24 – 6/18 visual acuity, on Day 7, 66% had 6/12 – 6/6 visual acuity, on Day 45, 74% had 6/12 – 6/6 visual acuity and on Day 90, 96% had 6/12 – 6/6 visual acuity.

In Group B, on Day 1, 16 %of the patients had 6/12 – 6/6 visual acuity, on Day 7, 44% had 6/12 – 6/6 visual acuity, on Day 45, 62% had 6/12 – 6/6 visual acuity and on Day 90, 84% had 6/12 – 6/6 visual acuity.

Post-operatively mean VA was 0.42±0.18 LogMAR in group A (Frown incision group) and 0.66±0.30 LogMAR in group B (Straight incision group) on day 1, which changed to 0.19±0.13 LogMAR in group A and 0.24±0.14 LogMAR in group B on day 90.

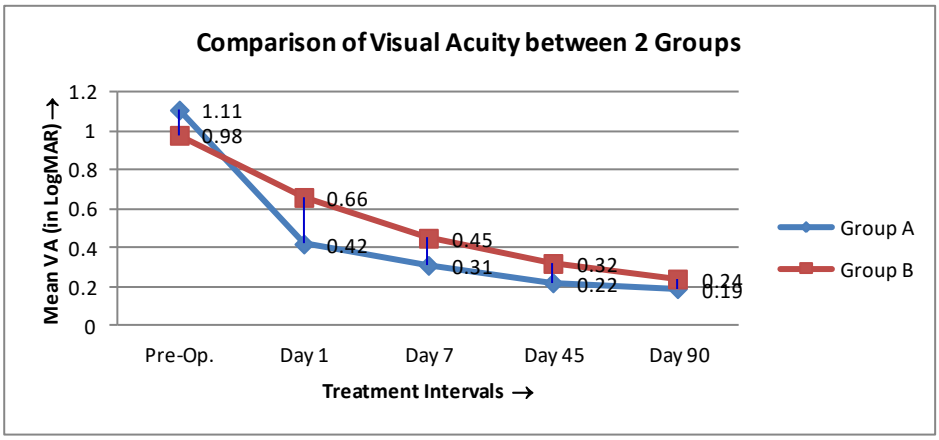

Figure 1: Comparison of visual acuity between two groups.

Table 5: Range of surgically induced astigmatism

Range of SIA	Group A		Group B	
	No.	Percentage	No.	Percentage
0.00 – 0.5 D	12	24	9	18
0.75 – 1.0 D	21	42	10	20
1.25 – 1.5 D	13	26	13	26
1.75 – 2.0 D	2	4	8	16
2.25 – 2.5 D	1	2	4	8
2.75 – 3.0 D	1	2	3	6
3.25 – 3.5 D	0	0	3	6
Total	50	100	50	100

In Group A, majority of the patients (42%) had SIA in the range of 0.75D– 1.0 D, 26% were in the range of1.25 – 1.5 D, 24% were in the ranges of 0.00 – 0.5 D , 4% were in the range of 1.75 – 2.00 D and 2% were in the ranges of 2.25 – 2.5 D and 2.75 – 3.0 D each.

In Group B, majority of the patients (26%) had SIA in the range of 1.25– 1.5 D, 20% were in the range of 0.75 – 1.0 D, 18 % were in the range of 0.00 – 0.5D, 8% were in the range of 2.25 – 2.5 D and 6% were in the range of 2.75 D- 3.0 D AND 3.25 -3.5 D each.

Table 6: Comparison of amount of surgically induced astigmatism (SIA) between two groups at different time interval.

Variable	Day 1		After 7 days		After 45 days		After 90 days	
SIA (in Diopter)	Group A	Group B	Group A	Group B	Group A	Group B	Group A	Group B
Mean±SD	.91±.53	1.34±.72	1.07±.66	1.40±.72	.91±.54	1.32±.88	.83±.53	1.37±.92
Significance	p=0.001*		p=0.022*		p=0.007*		p=0.001*	

*Significant

The mean post-operative SIA was 0.91±0.53 Diopter and 1.34±0.72 Diopter in group A and group B respectively on day 1 ($p<0.05$) which changed to 0.83±0.53 Diopter and 1.37±0.92 Diopter in group A and group B respectively after day 90 ($p<0.05$).

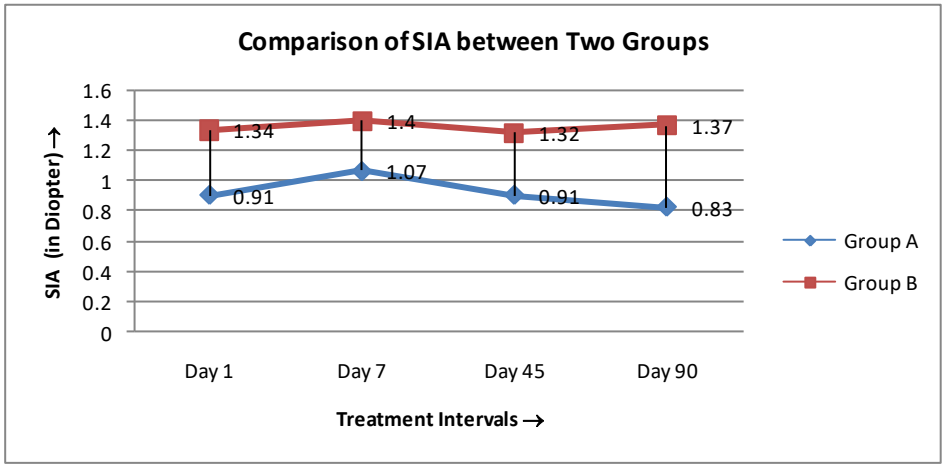

Figure 2: Comparison of surgically induced astigmatism (SIA) between two groups.

Table 7: Comparison of KH between two groups at different time interval.

Variable	Day 1		After 7 days		After 45 days		After 90 days	
KH	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2
Mean±SD	44.69±1.59	44.67±1.98	44.61±1.59	44.82±1.90	44.71±1.47	44.88±1.91	44.58±1.55	44.84±2.0
Significance	p=0.956		p=0.551		p=0.631		p=0.47	

Table 8: Comparison of KV between two groups at different time interval.

Variable	Day 1		After 7 days		After 45 days		After 90 days	
KV	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2
Mean±SD	45.18±1.69	44.36±2.16	45.21±1.77	44.35±2.12	45.19±1.69	44.26±2.12	45.19±1.65	44.23±2.07
Significance	p=0.038		p=0.029		p=0.017		p=0.012	

Table 9: Comparison of Axis rotation between two groups at different time interval.

Variable	Day 1		After 7 days		After 45 days		After 90 days	
Axis	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2
Mean±SD	126.60 ±44.24	126.20 ±47.97	115.80 ±44.54	131.60 ±48.67	103.20 ±51.48	131.60 ±57.97	94.20 ±40.66	142.80 ±47.93
Significance	p=0.966		p=0.094		p=0.011		p=0.000	

DISCUSSION

Cataract surgery has refined tremendously in recent years mainly to fulfill the expectation of the patients that is early visual rehabilitation and minimal induced astigmatism. Modern day cataract surgery aims not only at the 'Restoration of sight' and 'Reduction of economic blindness' but on an 'Early restoration of optimum visual acuity' and therefore, a reduction in surgically induced astigmatism.

It is reported from previous studies that patients undergoing Manual SICS have an early visual rehabilitation. [13-15]

Phacoemulsification has become the most favoured procedure for cataract surgery in industrialized countries. In developing countries, Manual Small Incision Cataract Surgery is the most favoured procedure.

Several variables exist in creation of the wound for cataract surgery, such as location (corneal versus scleral), direction (superior, temporal or oblique), width, depth and shape. Modern techniques not only minimize this astigmatism but also constructively alter the type of astigmatism produced by surgery, i.e., in some cases the choice of incision may help in reducing a pre-existing toricity in the cornea. These factors allow the surgeon the ability to tailor the wound parameters to suit individual cases to achieve the goal of emmetropia.

Hence, modern cataract surgery, in its quest for providing the best uncorrected visual acuity to the patient and minimizing surgically induced astigmatism has become a refractive surgery today. With the goal not only to remove the cataract but also to minimize astigmatism induced by surgery and to reduce the preoperative astigmatism, if any, in the patient.

This is a randomized, prospective study conducted at the Department of Ophthalmology, ESIPGIMSR, Basai-darapur, New Delhi. The patients were randomly divided into two groups, that is Group A (patients who underwent MSICS with frown incision) and Group B (patients who underwent MSICS with straight incision). In addition to visual acuity measurement, slit lamp examination and fundus examination, keratometry was a part of pre and post operative follow up.

Pre-operative and post-operative keratometric readings were used for analysis. Surgically Induced Astigmatism (SIA) was calculated using a computer program (software) called 'SIA Calculator 1.0'

The aim of this study is to compare the surgically induced corneal astigmatism in patients undergoing manual small incision cataract surgery by straight and frown incisions and to assess whether the difference by the two techniques is statistically significant.

The study included 100 patients adhering strictly to the inclusion and exclusion criteria, who underwent MSICS by frown scleral incision and straight scleral incision with IOL implantation by the same surgeon over a span of 1 year. Study patients were divided into two groups. 50 patients were randomized to the frown incision group and 50 were randomized to the straight incision group.

In the present study, majority of patients in Group A (%) were in the age group of 51-60 years and in Group B, majority (%) were in the age group of 51 – 60 years. The Male: Female ratio was 0.72:1 in Group A and in Group B it was 1:1.

In Group A, majority of the patients (42%) had SIA in the range of 0.75D– 1.0 D, 26% were in the range of 1.25 – 1.5 D, 22% were in the ranges of 0.00 – 0.5 D , 4% were in the range of 1.75 – 2.00 D and 2% were in the ranges of 2.25 – 2.5 D and 2.75 – 3.0 D each.

In Group B, majority of the patients (26%) had SIA in the range of 1.25– 1.5 D, 20% were in the range of 0.75 – 1.0 D, 18 % were in the range of 0.00 – 0.5D, 8% were in the range of 2.25 – 2.5 D and 6% were in the range of 2.75 D- 3.0 D AND 3.25 -3.5 D each.

In the present study, the average SIA recorded in Group A was 0.79 D with standard deviation of 0.63 D and in Group B

it was 1.35 D with standard deviation of 1.07 D . The calculated t value was found to be 2.8990. This value is more than the standard value, i.e. 2.66. P value accordingly < 0.01 which is highly significant. The SIA induced by the straight incision was % more than the frown incision.

KN Jha et al [16] in their study on manual SICS using 6 mm straight incision with 69 cases of cataract reported 85.5% of patients with astigmatism up to 1 D, with only 8.7% cases having astigmatism more than 2 D.

On the 1st post operative day, 16.67% of the patients in Group A and 50% of the patients in Group B had visual acuity between 6/12 to 6/6.

After 1 week, 56.67% of the patients of Group A and 70% of the patients in Group B had visual acuity between 6/12 to 6/6.

After 45 days (one and a half month), 76.77% of the patients in Group A and 90% of the patients in Group B had visual acuity between 6/12 – 6/6.

At the end of the study, i.e. 90 days (3 months), 80% of the patients in Group A and 93.33% of the patients in Group B had visual acuity between 6/12 – 6/6.

The UCVA was better in the frown incision group as compared to the straight incision group. Similar results have been reported in several studies.

High astigmatism is an important cause of poor uncorrected visual acuity after cataract surgery. [17]

The results of this study show that there is minimal astigmatism in MSICS and that SIA can be modified by modification of the incision location.

It is generally reported that the corneal astigmatism is WTR in young eyes and there is a shift towards ATR as age advances. It has been suggested that the upper and lower lids compress the cornea and causes steepening of the vertical curvature. But with advancing age, the compressive effect of the lids is lessened by lid laxity and low rigidity. The goal of any surgery involving the cornea is to achieve regular spherical emmetropia. [18]

CONCLUSION

The following conclusions were drawn from the study.

The incidence of post operative astigmatism following MSICS with PCIOL implantation with frown incision is less than straight incision.

The mean SIA was less with frown incision as compared to straight incision.

In Group A (frown incision group), the mean SIA was 0.83±0.53 D and in Group B (straight incision group), the mean SIA was 1.37±0.92 D post-operatively after 90 days.

The comparison between the mean of the two groups using ‘unpaired t test’ was statistically significant ($p<0.05$) indicating that group B had more SIA.

In the present study, the visual rehabilitation was similar in both the groups. The UCVA was better in frown incision as compared to straight incision group.

We observed that there is a flattening of the meridian in which the incision is made.

In conclusion, the frown incision is evidently better than the straight incision in minimizing surgically induced astigmatism.

Limitations of the Study

The sample size is small – consisting of only 50 patients in each group.

The period of follow-up was too short. Other studies have a 2 year post operative follow-up.

Corneal topographic changes were not analysed in the study.

Recommendations

Similar study with a bigger sample size and an extended follow-up period would focus more light on the post operative SIA with temporal incision.

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