

Research Article

Comparison of surgically induced astigmatism in corneo-scleral and clear corneal incision in phacoemulsification

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ABSTRACT

Background: The objective of the study was to determine and compare the surgically induced astigmatism in patients who have undergone phacoemulsification with clear corneal and corneoscleral incisions made superiorly and temporally.

Methods: Study was conducted in 100 patients who underwent cataract surgery from a period of November 2012 to July 2014. They were evaluated pre and post-operatively. Pre-op and Post-op Vision, retinoscopy and keratometry were analysed and surgically induced astigmatism was calculated using Vector method.

Results: Surgically induced astigmatism calculated with SIA Calculator using Holladay's method was as follows; Superior corneoscleral 0.79 D, Temporal corneoscleral 0.52 D, Superior clear corneal 0.60 D, Temporal clear corneal 0.73 D. A higher incidence of against the rule astigmatism was seen pre-operatively (45%) and post-operatively (42%).

Conclusions: From our study, we have concluded that no significant difference was seen in the surgically induced astigmatism following phacoemulsification in all four incisions though the least SIA value was obtained with Temporal corneo-scleral. To conclude, temporal corneo-scleral incisions being farther away from the visual axis has minimal effect on the corneal curvature with near astigmatic neutrality.

Keywords: Surgically induced astigmatism, Clear corneal incision, Corneo-scleral incision, Keratometry

INTRODUCTION

Astigmatism is a common refractive error in which the refraction varies in different meridians. Aetiology could be of corneal, lenticular or retinal types. Corneal astigmatism has always been a by-product of cataract surgery.^{1,2,3}

Post cataract corneal astigmatism causes a delay in visual rehabilitation, limiting the visual outcome and reduces the effectiveness of the surgical procedure.²

The change of surgical techniques from Intracapsular Cataract Extraction (ICCE) to Extra capsular Cataract

extraction (ECCE) to Small Incision Cataract Surgery (SICS) and to finally Phacoemulsification have caused a drastic change in the ability to predict and hence control the post operative astigmatism.^{2,3} Use of newer modalities like Femtosecond laser cataract surgery helps in more precise limbal relaxing incisions with excellent incision architecture and minimal residual corneal astigmatism. Factors like location, direction, length, width, depth and shape of the incision, types of suture and suture materials have been found to influence the astigmatism; of which various studies have shown that width, depth and shape have very little effect on the amount of astigmatism.³⁻⁶

An incision of cornea or sclera creates tissue gape. Gape produced by limbal incision causes corneal flattening along the meridian of incision and steepening in the meridian 90 degree away depending on length of incision and location relative to center of cornea. Low induced astigmatism, faster healing of corneal wound and no direct damage to the cornea justify the usage of small self sealing sclero-corneal tunnel incision.⁷⁻²⁰

Corneo-scleral or Limbal incisions are made between the mid limbal line and the posterior limbal border. This is mainly to enhance wound healing and to exert less traction on the cornea, hence controlling the surgically induced astigmatism. Self-sealing scleral tunnel incisions vary with respect to width and configuration of the groove- from circumlimbal to straight to chevron (frown) shaped.^{13,22,25,30}

Clear corneal incisions are made in front of the anterior limbal border ; have advantages of shorter tunnel length, an external direct entrance anterior to limbus, the abolition of need of cautery, choice of using topical anaesthesia with no or minimal bleeding, less discomfort and faster recovery of wound.^{23,25,26,27}

In this study, we have determined and compared the keratorefractive changes in phacoemulsification following different incision types on different locations of the cornea ie superior clear corneal, temporal clear corneal, superior corneo-scleral and temporal corneo-scleral incisions.

METHODS

The above prospective interventional hospital based study was conducted in patients who were undergoing phacoemulsification with foldable intraocular lens implantation (maintaining the inclusion, exclusion criteria) in our department. Patients with intra-operative or post-operative complications were excluded from the study.

Study was conducted among a total of 100 patients who had cataract and willing to follow the study protocol .They were randomly assigned to a group of four, each group consisting of 25 patients. Group A consisted of 25 patients who underwent phacoemulsification with Temporal corneo-scleral incision, Group B of 25 patients with Superior corneo-scleral incision, Group C was 25 patients with Temporal clear corneal and Group D of 25 patients with Superior clear corneal.

Study was conducted over a period of 20 months. Patients with ocular surface disorders, on immuno suppressive therapy or on chronic topical medications were excluded. Patients diagnosed of collagen vascular diseases or with previous refractive ocular surgeries were also excluded from the above study.

Preoperative detailed workup was done including keratometry and intraocular lens power calculation. Phacoemulsification with a common incision size of 2.8 x 2.0 mm with the help of a keratome was used for all the surgeries.

Corneo-scleral incision: A fornix based conjunctival flap was made. The area on the corneo-scleral bed was marked with vernier calipers 2.8mm. Incision was made using number 11 blade. Crescent shaped blade helped in tunneling the wound for 2 mm. Entry into the anterior chamber made with a 2.8 mm keratome. Viscoelastic injected and the procedure completed.



Figure 1: Corneo-scleral incision.

Clear corneal incision: Incision was made through the cornea at the anterior edge of the vascular arcade (superiorly or temporally) based on the location of incision by using the keratome (2.8 mm). By depressing the posterior lip of the groove the point of keratome is slide into the cornea for 2 mm and entry into the anterior chamber made. Procedure completed.



Figure 2: Clear corneal incision.

Post-operative period was managed with steroid and antibiotic drops, tapered gradually. Evaluation was done on first post-operative day, 1 week and 4 weeks post operatively. Vision, Retinoscopy, Keratometry, anterior and posterior segment examination was done. Uncorrected and best corrected visual acuity was assessed at post-op 4th week. SIA was calculated by Holladay's technique using the SIA calculator.

Statistics

Data entry was done using Microsoft Excel 2007. Analysis by SPSS version 17. ANOVA (analysis of variance) test, chi-square test, T test, Kruskal Wallis test and Z test for proportion was used for statistical analysis with the help of the statistician.

RESULTS

Study included maximum patients ranging in the age group of 61-70 years with a mean age of 65 in Group A, 64 in Group B, 61 in Group C and 62 in Group D. (Table 1). On comparison of the pre-operative and post operative 4 weeks astigmatism, although statistically no significant difference is seen among the four groups, Group A (Temporal corneo-scleral) showed a decrease in the post operative 4 week astigmatism from 1.0 D to 0.7 D, Group B 0.6 D to 0.8 D, Group C and Group D from 0.8 to 0.6D (Table 2).

Table 1: Age Incidence.

Age	Temporal corneo-scleral incision (Group A)	Superior corneo-scleral incision (Group B)	Temporal clear corneal incision (Group C)	Superior clear corneal incision (Group D)
35 – 50	2 (8)	2 (8)	6 (24)	4 (16)
51 – 60	5 (20)	8 (32)	6 (24)	7 (28)
61 – 70	11 (44)	8 (32)	6 (24)	10 (40)
>70	7 (28)	7 (28)	7 (28)	4 (16)
Mean ± SD	65 ± 8.5	64.1 ± 10.6	60.5 ± 12.9	61.8 ± 10.4

Table 3: Type of Astigmatism in Group A (Temporal corneo-scleral).

Type of astigmatism	Pre op		Post op 4 weeks	
	Count	Percent	Count	Percent
With The Rule Astigmatism	4	16.0	4	16.0
Against The Rule Astigmatism	15	60.0	13	52.0
Oblique Astigmatism	5	20.0	5	20.0
No astigmatism	1	4.0	3	12.0

Table 2: Pre and post operative astigmatism.

		Mean	SD	N	F	p
Pre op	Temporal corneo-scleral incision	1.0	0.9	25	1.34	0.267
	Superior corneo-scleral incision	0.6	0.5	25		
	Temporal clear corneal incision	0.8	0.7	25		
	Superior clear corneal incision	0.8	0.6	25		
Post Op 1 week	Temporal corneo-scleral incision	1.1	0.7	25	1.32	0.274
	Superior corneo-scleral incision	0.8	0.5	25		
	Temporal clear corneal incision	0.8	0.7	25		
	Superior clear corneal incision	0.8	0.5	25		
Post Op 4 week	Temporal corneo-scleral incision	0.7	0.6	25	0.85	0.471
	Superior corneo-scleral incision	0.8	0.6	25		
	Temporal clear corneal incision	0.6	0.5	25		
	Superior clear corneal incision	0.6	0.5	25		

In Group A, Pre-operative Against the rule (ATR) (60%) and post-operatively 52% had ATR. With the rule (WTR) and Oblique remained approximately same pre and post-operatively (Table3). In Group B, 52% have ATR, which on Post op becomes 60%. 8 % have WTR, 20 % Oblique and 12 % no Astigmatism (Table 4).

In Group C, 32 % have WTR and 32 % have Oblique Astigmatism. 24 % have ATR astigmatism and 12 %

have no astigmatism (Table 5). In Group D, although pre-operatively a higher incidence of WTR astigmatism was seen (44%), post op 4 weeks 32 % had WTR and 32 % had ATR. 24 % had Oblique and 12 % No Astigmatism (Table 6).

Table 4: Type of Astigmatism in Group B (Superior corneo-scleral).

Type of Astigmatism	Pre op		Post op 4 week	
	Count	Percent	Count	Percent
With the rule Astigmatism	4	16.0	2	8.0
Against the rule Astigmatism	13	52.0	15	60.0
Oblique Astigmatism	6	24.0	5	20.0
No astigmatism	2	8.0	3	12.0

Table 5: Type of Astigmatism in Group C (Temporal Clear Corneal).

Type of astigmatism	Pre op		Post op 4 week	
	Count	Percent	Count	Percent
With the rule Astigmatism	6	24.0	8	32.0
Against the rule Astigmatism	11	44.0	6	24.0
Oblique Astigmatism	7	28.0	8	32.0
No astigmatism	1	4.0	3	12.0

Table 6: Type of Astigmatism in Group D (Superior Clear Corneal).

Type of astigmatism	Pre op		Post op 4 week	
	Count	Percent	Count	Percent
With the rule Astigmatism	11	44.0	8	32.0
Against the rule Astigmatism	6	24.0	8	32.0
Oblique Astigmatism	6	24.0	6	24.0
No astigmatism	2	8.0	3	12.0

Surgically Induced Astigmatism among the various groups was mainly based on the differences in location of the incision with a fixed incision size of 2.8mm x 2.0 mm. Though the differences in SIA among the groups showed no statistical significance ($p > 0.05$), the mean

value of SIA was found to be the lowest with Temporal corneo-scleral incision $-0.52 D \pm 0.29 D$ (Table 7).

SIA Coherence values compares the SIA values among the various groups. On comparison, Group A vs Group D was statistically significant ($p < 0.05$), Group B vs Group D and Group C vs Group D showed statistical significance ($p < 0.05$) (Table 8).

This infers that for a fixed size of incision, Temporal corneo-scleral, Superior corneo-scleral and Temporal clear corneal had no statistical significance among the SIA values- so they all produce very minimal SIA. But for the same fixed incision, Superior clear corneal produces a significant amount of surgically induced astigmatism.

Table 7: Comparison of SIA based on type of incision.

Group	Mean	SD	N	F	P
Temporal corneo-scleral incision	0.52	0.29	25	1.34	0.266
Superior corneo-scleral incision.	0.79	0.67	25		
Temporal clear corneal incision	0.73	0.71	25		
Superior clear corneal incision	0.60	0.37	25		

Vision assessed pre-operatively showing a mean visual acuity of LogMar 1.0 (6/60 on Snellen's optotype) as determined by the Kruskal Wallis Test (Table 9).

88% of patients in Group D had Best corrected visual acuity as LogMar 0.0 (6/6 of Snellen's) and 80 % in Group A and Group B had BCVA of LogMar 0.0 as determined by the Kruskal Wallis Test (Table 10).

SIA though not statistically significant, was found to be lower in Group A (Temporal corneo-scleral) compared to the rest, BCVA in Group A was 80% which could be due to pre-existing ocular causes.

Table 8: Comparison of SIA Coherence values.

Group	Mean	Pair	Z	p	Pair	Z	p
Temporal corneo-scleral incision (A)	48	A Vs B	0.355	0.726	B Vs C	1.504	0.134
Superior corneo-scleral incision (B)	43	A Vs C	1.847	0.066	B Vs D	2.531 *	0.011
Temporal clear corneal incision (C)	23	A Vs D	2.197 *	0.029	C Vs D	3.889**	0.000
Superior clear corneal incision (D)	78						

**:- Significant at 0.01 level *:- Significant at 0.05 level

Table 9: Comparison of Pre-op Vision among the groups.

Pre Op vision	Temporal corneo-scleral incision	Superior corneo-scleral incision.	Temporal clear corneal incision	Superior clear corneal incision	$\chi^2\#$	p
0.3	0 (0)	1 (4)	0 (0)	0 (0)	2.2	0.532
0.4	2 (8)	0 (0)	0 (0)	0 (0)		
0.5	0 (0)	0 (0)	1 (4)	2 (8)		
0.6	0 (0)	1 (4)	2 (8)	2 (8)		
0.7	1 (4)	1 (4)	0 (0)	0 (0)		
0.8	6 (24)	3 (12)	4 (16)	3 (12)		
0.9	0 (0)	0 (0)	0 (0)	3 (12)		
1.0	5 (20)	6 (24)	8 (32)	7 (28)		
1.2	0 (0)	1 (4)	0 (0)	1 (4)		
1.3	5 (20)	3 (12)	4 (16)	3 (12)		
1.5	6 (24)	9 (36)	6 (24)	4 (16)		
Mean \pm SD	1.1 \pm 0.3	1.1 \pm 0.3	1.1 \pm 0.3	1 \pm 0.3		
Median	1.0	1.2	1.0	1.0		

Table 10: Comparison of Best Corrected Visual Acuity.

BCVA	Temporal corneo-scleral incision	Superior corneo-scleral incision.	Temporal clear corneal incision	Superior clear corneal incision	$\chi^2\#$	p
0.0	20 (80)	20 (80)	19 (76)	22 (88)	1.34	0.721
0.1	3 (12)	4 (16)	5 (20)	3 (12)		
0.2	2 (8)	1 (4)	0 (0)	0 (0)		
0.3	0 (0)	0 (0)	1 (4)	0 (0)		
Mean \pm SD	0 \pm 0.1	0 \pm 0.1	0 \pm 0.1	0 \pm 0		
Median	0.0	0.0	0.0	0.0		

DISCUSSION

The present study was done to determine and compare the amount of surgically induced astigmatism following phacoemulsification with a fixed incision size of 2.8 mm x 2.0mm on 4 different locations, i.e, Temporal corneo-scleral, Superior corneo-scleral, Temporal clear corneal and Superior clear corneal. Comparison of the amount of pre-operative and post-operative astigmatism has been done. Uncorrected and Best corrected visual acuity at 4-6 weeks has also been described taking into account the pre-operative astigmatism.

Out of the 100 patients who were studied, the surgically induced astigmatism for the incisions of fixed size and differing location was not found to be statistically significant. Repeated measures of ANOVA were used for analysis and the p value was found to be more than 0.05. Out of the mean SIA values calculated, Temporal corneo-scleral incision was found to have the lowest value of 0.52 D with a standard deviation of 0.29 D.

Describing the astigmatism seen with our study, Pre-operatively there was a higher incidence of ATR astigmatism 45%, WTR astigmatism was 25%, Oblique 24% and No astigmatism 6%. At the end of 1 and 4 weeks 42% had ATR astigmatism, 24% having Oblique astigmatism, 22% having WTR astigmatism and 12% with No astigmatism.

In Temporal corneo-scleral incision, at the end of 4-6 weeks 52% had ATR astigmatism, 20 % Oblique, 16% WTR astigmatism and 12% No astigmatism. In Superior corneo-scleral incision, 60% had ATR astigmatism, 20% having Oblique astigmatism, 12 % having No astigmatism and 8% with WTR astigmatism. In Temporal clear corneal, 32 % were seen with WTR and Oblique astigmatism, 24% with ATR astigmatism and 12% with No astigmatism. In Superior clear corneal incision, 32% were seen having WTR and ATR astigmatism, 24% with Oblique astigmatism and 12% with No astigmatism.

Generally the corneal astigmatism seen is with-the-rule in young patients and there is a shift towards against-the-rule astigmatism as age advances. With the rule

astigmatism in younger age can be due to the upper and lower lids compressing a portion of the cornea and causing steepening of the vertical curvature. But as age advances - the compressive effect of the lids is lessened by lid laxity, decreased tone of Muller's muscle and increased corneal rigidity. The goal of the surgery is to achieve spherical emmetropia.³ The central optic zone of cornea has a maximum power of +48.83 D with the anterior radius of curvature 7.7 mm and posterior radius of curvature 6.8 mm. As radius of curvature decreases, the power in that meridian increases.^{14,15}

The Superior incisions showed ATR astigmatism and Temporal incisions WTR astigmatism, an overall increased incidence of ATR astigmatism (42%) was seen due to the higher incidence of pre-existing ATR astigmatism (45%). On comparing Temporal corneo-scleral incision with Temporal clear corneal, the WTR astigmatism seen was higher for Temporal clear corneal (32%) compared to that in Temporal corneo-scleral incision(16%).¹⁶⁻¹⁹

The optical center of the cornea is not identical to the geometrical center; optical center is located closer to the center of the cornea .Therefore, incision closer to the center produces greater astigmatic changes than farther ones.^{22,23,33}

Similarly, on comparing the Superior corneo-scleral incision and clear corneal incision, ATR was found to be 60% in Superior corneo-scleral and 32% in Superior clear corneal incision.Superior clear corneal incision tends to produce more ATR astigmatism than corneo-scleral incision, but pre-operatively the incidence of ATR astigmatism was 52% in Superior corneo-scleral group and 24% in clear corneal group. Higher incidence seen in the Superior corneo-scleral group could be due to this pre-existing ATR astigmatism.²⁰⁻²⁶

With a pre-existing high degree of WTR astigmatism, superior incisions should be considered. Temporally placed incisions are best preferred for cases of pre-operative ATR astigmatism. It has superior advantages in deep-set eyes and when considering filtering surgery in the superior limbal area as a later option.²⁸⁻³²

The clear corneal incision has many advantages- it is quick and easier to perform, allows better visualisation during surgery, and results in minimal bleeding besides self-sealing property. Because of foldable intraocular lens and down-sized phacoemulsification tips, this technique is the procedure of choice for immediate rehabilitation of vision.³⁴⁻³⁸

The temporally placed incision has an advantage, since distance from the visual axis to the periphery in the horizontal meridian is longer than for others on the cornea. Therefore, flattening at this incision is less likely to be transmitted to the visual axis- resulting in significantly lower SIA. When the incision is located

superiorly, both gravity and eye-blink tend to create a drag on the incision. These are neutralized with a temporally placed incision, because it is parallel to the vector of the forces. WTR astigmatism induced by a temporal incision is advantageous since most elderly have cataract with a pre-operative ATR astigmatism.

CONCLUSION

In a fixed incision of 2.8mm SIA among the groups of corneo-scleral and clear corneal was not statistically significant. But the mean SIA was lowest in Temporal corneo-scleral indicating that is comparatively the favourable site for incisions.

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