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Analysis of Astigmatism in Manual Small Incision Cataract Surgery through Superior and Temporal Incision Sites

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Abstract: Cataract can be corrected by Small Incision Cataract Surgery (SICS) as well as by Phacoemulsification. Instrumentation is very costly for phacoemulsification, hence many are preferring SICS but the drawback is astigmatism after SICS. This can be minimized by selecting the correct incision site during the surgery so as to minimize the incidence of astigmatism and for this a randomized control study was conducted with 100 patients and incisions for cataract surgery were made at different sites to find out a correct site to reduce the astigmatism in a very effective way. The patients were divided into 2 groups and Group I received superior incision and Group II a temporal incision. Preoperatively a complete ophthalmic examination including keratometry and 'A' scan biometry were done. Manual SICS with phacosandwich technique was used. Patients were examined on days 7, 30 and 45 after the surgery. Uncorrected and Best-Corrected Visual Acuity (UCVA and BCVA) and keratometry were recorded on each visit. Comparison of mean BCVA, one week after surgery of Group I (1.84 ±1.06) with that of Group II (1.12 ±0.33) showed statistical significance ($p < 0.001$). Comparison of mean BCVA at 4 weeks after surgery of Group I (1.36 ±0.66) with that of Group II (1.12 ±0.33) also showed statistical significance ($p < 0.05$). Hence it is concluded that temporal scleral incision produces lesser astigmatism compared to superior scleral incision in below 2.0 keratometric astigmatism and also an incision in the steeper meridian produces less astigmatism.
Keywords: Cataract, Small Incision Cataract Surgery, Phacoemulsification, Astigmatism, Keratometry, UCVA, BCVA, Temporal Incision, Superior Incision.

INTRODUCTION

Modern cataract surgery aims to achieve a better unaided visual acuity with rapid post-surgical recovery and minimal surgery related complications. The World Health Report [1] published in 1998 estimated that there were 19.34 million people who are bilaterally blind (less than 3/60 in the better eye) from age related cataract. This represented 43% of all blindness. The number of blind people in the world and the proportion due to cataract is increasing due to population growth and increasing longevity. Minassian and Mehra estimated that for India alone 3.8 million people become blind from cataract each year [2]. The number of cataract surgeries performed per year, per million populations is called Cataract Surgical Rate (CSR) [3-5]. The CSR in 1989-1990 in India was 1342/million while in 2001 it was 3620/million [6]. This has further increased to 4500 per million population in 2005 [7]. India has dramatically increased its CSR in the last 10 years from less than 1500 to a figure of around 3000 today. However, there is little evidence as yet that this CSR of 3000 in India is sufficient to keep pace with the incidence of cataract causing acuity of less than 6/60. The available figures for cataract surgery in India over the period 1989-2005, show that there has been an increase of 238,000 surgeries per year over the 16-year period. It is possible to achieve good rates if good quality cataract surgery is performed at a reasonable cost, close to where people live.

Early visual rehabilitation, better unaided visual acuity and surgical safety can be achieved in a great measure by reducing the incision size. Incision size depends on the mode of nucleus delivery and the type of intraocular lens used. It is about 10-12 mm in standard extracapsular surgery, about 5.5 mm to 7.0 mm in manual small incision surgery and about 3 mm in phacoemulsification, depending upon the technique and implant. The advantages associated with the smaller incision have made phacoemulsification the ideal technique for cataract surgery and the preferred one

where the resources are available. However, this technique cannot be employed as the standard procedure in developing countries due to many reasons. Manual small incision cataract surgery (SICS) offers similar advantages with the merits of wider applicability, better safety, a shorter learning curve and lower cost. Phacoemulsification requires expensive instrumentation which may not be available at all centers, whereas manual SICS requires only a minimum addition to the standard cataract surgery instrument armamentarium. Capsulorrhexis is mandatory for phacoemulsification, whereas manual SICS can be comfortably done with the can-opener or the envelope capsulotomy skills acquired previously. Surgically induced astigmatism following phacoemulsification and manual SICS have been found to be comparable, the difference between groups not reaching statistical significance in a recent large study [8]. The cost of a foldable Intra Ocular Lens (IOL) is much higher, placing it out of the reach of many of our patients. Disadvantages of rigid IOLs of a small size are well known. A standard large optic rigid IOL can be used with ease with manual SICS. The final visual acuity has been observed to be similar after both techniques. Another advantage of manual SICS over other methods of cataract surgery is the shorter duration taken, making it particularly applicable to high volume cataract surgery [9]. Studies have shown that manual SICS is clearly more cost effective than the alternatives [10,11] which includes large incision extracapsular cataract extraction [12,13]. To obtain the advantages of a self-sealing suture-less incision at a low cost, ophthalmic surgeons in the developing world are performing manual small incision cataract surgery. However, the drawback of this procedure is the precipitation of astigmatism with poor uncorrected visual acuity after the surgery. Based on these facts a study has been designed to reduce the incidence of astigmatism after SICS by making the incision at different sites and to find out a correct site were the incision can be made so as to reduce the astigmatism in a very effective way.

MATERIALS AND METHODS

This is a randomized control trial with 100 patients (age ranges from 50-70 with mean age of 60 years) admitted in Regional Institute of Ophthalmology, Trivandrum. Patients with keratometric astigmatism below 2.5 D, good fixation and cataract up to Grade II to Grade III nuclear sclerosis were included in the study. Those with glaucoma, uveitis and keratometric astigmatism above 2.5 D and nuclear sclerosis above Grade III, were excluded. Written informed consent was obtained from the patients prior to the study and the study was approved by the Institutional Ethics Committee.

A total of 100 patients were randomly divided into two groups of 50 each. Group I received superior incision and Group II received a temporal incision. Preoperatively a complete ophthalmic examination including keratometry and 'A' scan biometry were done. All surgeries were done by one surgeon under peribulbar anaesthesia. Manual SICS with phacosandwich technique was used. The incision architecture was similar in both the groups. A 6 mm straight incision, 1.5 mm from the limbus was made with a 15 number Bard Parker blade. A sclerocorneal pocket incision was created with a crescent blade. With a keratome, the anterior chamber was entered 1.5 mm into the clear cornea and the internal incision was enlarged sideways to 8 mm. A single piece Poly Methyl Methacrylate intraocular lens of 6mm optic size and 12.5 mm total size was implanted into the capsular bag after nucleus delivery by phacosandwich technique. Patients were examined on days 7, 30 and 45. Dexamethasone eye drops was administered six times a day in the first postoperative week and gradually tapered every week over six weeks. Gatifloxacin eye drops 0.3% was administered four times a day for the first ten days and then discontinued. Uncorrected and best-corrected visual acuity (UCVA and BCVA) and keratometry (Bausch and Lomb) were recorded on each visit. There were no intraoperative or postoperative complications. All patients were followed up without any dropout. Preoperative and postoperative keartometric readings and refraction were used for the analysis. Amplitude of preoperative and postoperative astigmatism was calculated from the difference in the keratometric value in the steeper and flatter meridian, using the plus cylinder notation.

Data were analyzed using computer software, Statistical Package for Social Sciences (SPSS) version 11. Data are expressed in its frequency and percentage as well as mean and standard deviation. To elucidate the associations and comparisons between different parameters, Chi square test was used as nonparametric test. Student's t-test was used to compare mean values between two groups. For all statistical evaluations, a two-tailed probability of value, <0.05 was considered significant.

OBSERVATIONS AND RESULTS

On comparing patients with pre-operative astigmatism of $1.50/90^{o}$ (Table 1, 2, 3 and 4), most of the patients in Group I had keratometric astigmatism of $0.75/180^{o}$ in 1^{st} week and 4^{th} week which changed to $0.50/180^{o}$ in the 6^{th} week in contrast to Group II which showed astigmatism between $1.50/90^{o}$ to $2.50/90^{o}$ in the 1^{st} week which stabilized at $1.25/90^{o}$ to $1.5/90^{o}$. The comparison was statistically significant.

Table-1: Pre-operative Astigmatism

Pre-operative Astigmatism	Superior Incision	Temporal Incision	Total
1.50 / 90 ^{o}	7	7	14
	14.00%	14.00%	14.00%
1.50 / 180 ^{o}	11	27	38
	22.00%	54.00%	38.00%
2.00 / 90 ^{o}	21	5	26
	42.00%	10.00%	26.00%
2.00 / 180 ^{o}	11	11	22
	22.00%	22.00%	22.00%

Chi square: 16.583; p <0.01

Table-2: Comparison of pre-operative astigmatism and astigmatism 1 week after surgery

	Pre-operative Astigmatism	Astigmatism 1 week after surgery																	
		Zero	0.25 / 90	0.25 / 180	0.50 / 90	0.50 / 180	0.75 / 90	0.75 / 180	1.00 / 180	1.50 / 90	1.75 / 90	2.00 / 90	2.00 / 180	2.25 / 90	2.25 / 180	2.50 / 90	2.75 / 180	3.00 / 180	3.25 / 180
Superior Incision	1.50 / 90	-	-	-	-	-	-	6	1	-	-	-	-	-	-	-	-	-	-
								100 %	100 %										
	1.50 / 180	-	-	-	-	-	-	-	-	-	-	-	9	-	2	-	-	-	-
													100 %		100 %				
	2.00 / 90	-	-	-	13	-	8	-	-	-	-	-	-	-	-	-	-	-	-
					100 %		100 %												
	2.00 / 180	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	2	1
																	100 %	100 %	100 %
Temporal Incision	1.50 / 90	-	-	-	-	-	-	-	-	1	1	1	-	2	-	2	-	-	-
										100 %	100 %	50.0 %		100 %		33.3 %			
	1.50 / 180	3	10	1	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		100 %	100 %	100 %	100 %														
	2.00 / 90	-	-	-	-	-	-	-	-	-	-	1	-	-	-	4	-	-	-
												50.0 %				66.7 %			
	2.00 / 180	-	-	-	-	10	-	1	-	-	-	-	-	-	-	-	-	-	-
						100 %		100 %											

Chi square: Superior incision: 150.00; p < 0.001Temporal incision: 118.571; p < 0.0

On comparing patients with pre-operative astigmatism of 1.50/180^{o} (Table 1, 2, 3 and 4), patients in Group I showed keratometric astigmatism of 2.0/180^{o} to 2.25/180^{o} in the 1st week which changed to 1.75/180^{o} in 4th week and 1.25/180^{o} to 1.50/180^{o} in the 6th week. This is in contrast to Group II which showed most of the patients to be having 0.25/90^{o} in 1st and 4th week which changed to no astigmatism in the last follow-up visit. This was also statistically significant. In patients with pre-operative keratometric astigmatism of 2.0/90^{o} (Table 1, 2, 3 and 4), majority of Group I showed 0.50/180^{o} during all the follow-up visits in comparison to Group II majority of which showed 2.0/90^{o} to 2.25/90^{o} during all the visits.

Table-3: Comparison of pre-operative astigmatism and astigmatism 4 weeks after surgery

	Pre-operative Astigmatism	Astigmatism 4 Weeks after surgery													
		Zero	0.25 / 90	0.50 / 90	0.50 / 180	0.75 / 90	0.75 / 180	1.00 / 90	1.50 / 90	1.75 / 90	1.75 / 180	2.00 / 90	2.25 / 90	2.50 / 90	2.75 / 180
Superior Incision	1.50 / 90	-	-	-	-	-	7	-	-	-	-	-	-	-	-
							100 %								
	1.50 / 180	-	-	-	-	-	-	-	-	-	11	-	-	-	-
											100 %				
	2.00 / 90	-	-	9	-	8	-	4	-	-	-	-	-	-	-
				100 %		100 %		100 %							
	2.00 / 180	-	-	-	-	-	-	-	-	-	-	-	-	-	11
															100 %
Temporal Incision	1.50 / 90	-	-	-	-	-	-	-	3	1	-	3	-	-	-
									100 %	100 %		75.0 %			
	1.50 / 180	4	23	-	-	-	-	-	-	-	-	-	-	-	-
		100%	100 %												
	2.00 / 90	-	-	-	-	-	-	-	-	-	-	1	3	1	-
												25.0 %	100 %	100 %	
	2.00 / 180	-	-	-	10	-	1	-	-	-	-	-	-	-	-
					100 %		100 %								

Chi square: Superior incision: 150.00; $p < 0.001$, Temporal incision: 137.143; $p < 0.001$

In patients with pre-operative keratometric astigmatism of 2.0/180^o (Table 1, 2, 3 and 4), Group I showed 2.75/180^o in the 1st and 4th week follow-up which changed to 2.25/180^o in the last follow-up. This was in contrast to Group II which showed 0.50/90^o in the first two visits and no astigmatism to 0.50/90^o in the last follow-up. The comparison was statistically significant.

All patients in Group I with 1.50 With the Rule (WTR) astigmatism changed to Against the Rule (ATR) at the end of the follow-up. But all with 2.0 WTR remained so at 6th week. In case of Group II, all patients with 1.50 and 2.0 WTR astigmatism remained so at the end of the follow-up. In Group I, patients with 1.50 and 2.0 ATR astigmatism remained ATR at 6th week follow-up. In Group II, all patients with ATR became either WTR or had no astigmatism (Table 4).

Table-4: Comparison of pre-operative astigmatism and astigmatism 6 weeks after surgery

	Pre-operative Astigmatism	Astigmatism 6 Weeks after surgery																
		Zero	0.25 / 90	0.25 / 180	0.50 / 90	0.50 / 180	0.75 / 90	1.25 / 90	1.25 / 180	1.50 / 90	1.50 / 180	1.75 / 180	2.00 / 90	2.00 / 180	2.25 / 180	2.25 / 180	2.50 / 90	2.50 / 180
Superior Incision	1.50 / 90	-	-	2	-	5	-	-	-	-	-	-	-	-	-	-	-	-
				50.0%		55.6%												
	1.50 / 180	-	-	-	-	-	-	-	4	-	4	2	-	1	-	-	-	-
									100 %		100 %	100 %		100 %				
	2.00 / 90	-	6	-	11	-	4	-	-	-	-	-	-	-	-	-	-	-
			31.6%		100 %		100 %											
	2.00 / 180	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	-	3
																100 %		100 %
Temporal Incision	1.50 / 90	-	-	-	-	-	-	3	-	4	-	-	-	-	-	-	-	-
								100 %		100 %								
	1.50 / 180	14	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		73.7 %	68.4%															
	2.00 / 90	-	-	-	-	-	-	-	-	-	-	-	2	-	2	-	1	-
													100 %		100 %		100 %	
	2.00 / 180	5	-	2	-	4	-	-	-	-	-	-	-	-	-	-	-	-
		26.3 %		50.0%		44.4%												

Chi square: Superior incision: 102.976; $p < 0.001$, Temporal incision: 126.431; $p < 0.001$

Comparison of mean pre-operative BCVA (Table 5) of Group I (10.02 ±3.12) with that of Group II (9.66 ±3.23) showed that it was statistically not significant ($p > 0.05$). Comparison of mean BCVA one week after surgery (Table 6) of Group I (1.84 ±1.06) with that of Group II (1.12 ±0.33) showed that it was statistically significant ($p < 0.001$). Comparison of mean BCVA at 4 weeks (Table 7) after surgery of Group I (1.36 ±0.66) with that of Group II (1.12 ±0.33) showed that it was statistically significant ($p < 0.05$). Comparison of mean BCVA 6 weeks after surgery (Table 8) of Group I (1.24 ±0.43) with that of Group II (1.12 ±0.33) showed that it was statistically not significant ($p > 0.05$).

Table-5: Pre-operative visual acuity

Parameters	Group	Mean	± SD	t value	p value
UCVA	Superior Incision	10.22	2.87	0.826	> 0.05
	Temporal Incision	9.72	3.17		
BCVA	Superior Incision	10.02	3.12	0.567	> 0.05
	Temporal Incision	9.66	3.23		

Table-6: Visual acuity 1 week after surgery

Parameters	Group	Mean	± SD	t value	p value
UCVA	Superior Incision	3.48	1.37	5.895	< 0.001
	Temporal Incision	2.08	0.97		
BCVA	Superior Incision	1.84	1.06	4.601	< 0.001
	Temporal Incision	1.12	0.33		

Table-7: Visual acuity 4 weeks after surgery

Parameters	Group	Mean	± SD	t value	p value
UCVA	Superior Incision	3.40	1.43	8.168	< 0.001
	Temporal Incision	1.56	0.70		
BCVA	Superior Incision	1.36	0.66	2.295	< 0.05
	Temporal Incision	1.12	0.33		

Table-8: Visual acuity 6 weeks after surgery

Parameters	Group	Mean	± SD	t value	p value
UCVA	Superior Incision	3.40	1.43	8.701	< 0.001
	Temporal Incision	1.44	0.70		
BCVA	Superior Incision	1.24	0.43	1.565	> 0.05
	Temporal Incision	1.12	0.33		

DISCUSSION

In the present study, 100 patients with cataract were included and they were randomly divided into two groups of 50 each depending upon the site of incision. The majority of both study groups came under 60-69 years. Males were significantly more in both the groups. Mean axial length and mean keratometric astigmatism were similar in both groups (p >0.05). They were followed up post-operatively at 1 week, 4 weeks and 6 weeks.

The World Health Organization (WHO) categorizes [14] the outcome of cataract surgery in three groups: good, borderline and poor and recommends aiming for a 'good', uncorrected visual acuity (VA) in at least 80% of surgeries, and 'poor' outcome in less than 5%. Both groups in the present study were in category I. BCVA was 98 % in 1st week and 100% in 4th and 6th weeks for Group I and UCVA was 88% during all three follow-up visits. In Group II, both UCVA and BCVA were 100% during all three follow-up visits. This shows that UCVA was better for Group II though BCVA was comparable in both groups. Pre–operative astigmatism was comparable between the two groups (p >0.05). In the present study, majority of patients with ATR showed less keratometric astigmatism in Group II compared to Group I and the result was reversed when pre-operative astigmatism was WTR. But the amplitude of astigmatism was significantly less in Group II compared to Group I. This is comparable to a study conducted by Nikhil S. Gokhale *et al*. in Mumbai [15] which showed that the amplitude of astigmatism in superior incision was less than that in temporal incision in pre- operative WTR. Yongqi He *et al.* [16] had published study which compared keratometric astigmatism in phacoemulsification through a clear temporal corneal incision and a superior scleral tunnel. It showed that superior scleral tunnel group had mean keratometric astigmatism of 1.09 ±1.03 and clear corneal temporal group had 1.56 ±0.94. This study showed that temporal incision was better than superior scleral incision. Reddy *et al*. [17] compared the astigmatism induced by superior and temporal incisions in manual SICS, and compared the astigmatism induced by clear corneal incision versus scleral tunnel in phacoemulsification surgery. Against the rule shift in astigmatism was found in the phacoemulsification group and the manual SICS superior incision group in their study. The manual SICS group with temporal incision had with-the-rule shift in astigmatism and this is comparable to our results. Ruit *et al*. [18] compared the efficacy and visual results of phacoemulsification vs SICS for the treatment of cataracts. They compared cases on parameters like operative time, surgical complications, uncorrected visual acuity (UCVA), BCVA, astigmatism, and central corneal thickness (CCT). They found that both the surgical techniques achieved excellent surgical outcomes with low complication rates. At six months, 89% of the SICS patients had UCVA of 20/60 or better and 98% had a BCVA of 20/60 or better vs 85% of patients with UCVA of 20/60 or better and 98% of patients with BCVA of 20/60 or better at six months in the phacoemulsification group (p = 0.30). This result is also comparable to our study. Gogate *et al*. [19] compared the efficacy, safety, and astigmatic change after cataract surgery by phacoemulsification and SICS. The intraoperative and postoperative complications, UCVA, BCVA, and astigmatism were recorded at 1 and 6 weeks postoperatively. They found that 68.2% patients in the phacoemulsification group and 61.25% patients in the SICS group had UCVA better than or equal to 6/18 at first week. At 6 weeks follow-up, 81.08% patients in the phacoemulsification group and 71.1% patients in the SICS group had UCVA of better than or equal to 6/18. This is in contrast to our study which showed a much better outcome in terms of UCVA more than or equal to 6/18 at 1 week and 6 weeks in both groups.

In another study conducted by Tetsuro Oshika *et al*. [20] compared the regular and irregular astigmatism in superior and temporal incision groups. They found that post-operatively slight ATR change was seen in superior incision group whereas WTR shift was seen in temporal incision group. There was no significant change in UCVA and BCVA in patients post-operatively (p >0.05). This is comparable to our result which showed similar result in patients with astigmatism below 2.0. Nagpal *et al*. [21] in a study

also found that there is ATR shift following superior scleral incision surgery similar to our study. A study carried out by Matsumoto Y *et al*. [22] showed that least post-operative astigmatism is seen if the incision is made in the steeper meridian. The same result is seen in our study where temporal incision in steeper horizontal meridian and superior incision in steeper vertical meridian produced less amount of astigmatism. Two independent studies by Spierer *et al*. [23] and Bar-Sela *et al*. [24] have evaluated children undergoing cataract surgery with preoperative astigmatism of 3D or more and have found out that there is a decline in postoperative astigmatism at 5 months follow up though the initial follow-up showed an increase in astigmatism.

CONCLUSIONS

The conclusions of the present study are, incision in the steeper meridian produces less astigmatism. Temporal scleral incision produces less astigmatism compared to superior scleral incision in below 2.0 keratometric astigmatism. Best corrected visual acuity was similar in both groups but Group II showed better uncorrected visual acuity than Group I. When the pre-operative astigmatism was 1.50 ATR, at 6 weeks Group I showed astigmatism comparable to pre-operative value but when pre-operative astigmatism was 2.0 ATR the astigmatism was slightly higher than the pre-operative value. Group II also got a similar result with 1.50 and 2.0 WTR pre-operative astigmatism.

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