Original Article

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Surgically Induced Astigmatism in Manual Small Incision Cataract Surgery Following Straight, Frown and Chevron Incision

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Abstract

Background: Surgically Induced Astigmatism (SIA) remains a major determinant of uncorrected visual acuity following manual Small-Incision Cataract Surgery (SICS). Incision configuration is a modifiable factor influencing postoperative refractive outcomes. To compare postoperative visual acuity and surgically induced astigmatism among straight, frown and chevron incisions in manual SICS.

Materials and methods: This prospective observational analytical study was conducted at a tertiary care hospital in Bangladesh from February 2022 to January 2023. A total of 110 patients aged 40 years with uncomplicated age-related cataract and with-the-rule astigmatism were enrolled. Patients underwent manual SICS using straight (n=37) frown (n=49) or chevron (n=24) incisions by a single experienced surgeon. Postoperative uncorrected and best-corrected visual acuity, keratometric astigmatism, and SIA were evaluated at six weeks. SIA was calculated using SIA Calculator version 2.1. Data were analyzed using SPSS version 25.0.

Results: Baseline demographic and preoperative visual parameters were comparable among groups. At six weeks, best-corrected visual acuity 6/18 was achieved in nearly all patients across all incision types. However, uncorrected visual acuity was significantly better in the frown and chevron groups compared to the straight incision group (p=0.034). Mean SIA was highest in the straight incision group (0.95 D) and significantly lower in the frown (0.58 D) and chevron (0.57 D) groups (p<0.001).

Conclusion: Frown and chevron incisions in manual SICS result in significantly lower surgically induced astigmatism and better early uncorrected visual outcomes compared to straight incisions. These incision techniques may be preferred to optimize refractive outcomes in high-volume, resource-limited settings.

Key words: Chevron; Frown; Incision; Manual small incision cataract surgery; Straight; Surgical induced astigmatism.

Introduction

Cataract is the most common cause of preventable blindness worldwide, and cataract surgery is the commonest operation performed in ophthalmology.[1] Cataract operation is also one of the most cost-effective surgery in terms of quality of life restored.[2] The prime aim of any cataract operation is visual rehabilitation and achieving the best uncorrected visual acuity. Cataract surgery unfolded from conventional Extracapsular Cataract Extraction (ECCE) to manual Small Incision Cataract Surgery (SICS) and then to phacoemulsification. While phacoemulsification becomes the most modern cataract surgery technique, manual SICS remains the technique of choice in many parts of the world where cost-effectiveness is a priority and surgical volumes are high.[3] Due to the high volumes of manual SICS in the advancing country, optimizing outcomes with this technique is vital.

However, despite its overall effectiveness, Surgically Induced Astigmatism (SIA) remains one of the key factors influencing uncorrected visual acuity and patient satisfaction following manual SICS.[4] SIA is astigmatism produced in an operated eye due to surgically induced corneal change. Several pre-, intra- and postoperative factors affect surgical-induced astigmatism in manual SICS. The preoperative factors comprise the type and magnitude of astigmatism and corneal and scleral changes. The intraoperative factors consist of the incision (Type, length, location and architecture) suture (Type and material) cauterization of the wound and tilt of the

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Intraocular Lens (IOL). The postoperative factors include wound healing, suture slippage and cutting, Intraocular Pressure (IOP) and wound dehiscence.[5] Of these, the type and placement of incision for manual SICS are important changeable factors studied in recent literature.[6]

To minimize postoperative astigmatism, manual SICS utilizes various scleral incision techniques.[7] Different shapes of external incision have been described namely smile, straight, frown/curved, Blumenthal side cuts, Inverted V/Chevron, etc.[5] These scleral pocket incisions are characterized by enhanced intra- and postoperative stability, which facilitates accelerated wound healing, rapid visual recovery and precise astigmatism management. Extensive research has been conducted to determine the optimal incision site and its subsequent impact on SIA.[7-11]

Although several studies have compared incision types in manual SICS, there remains a relative paucity of prospective data from Bangladesh evaluating both visual outcomes and SIA using standardized surgical techniques and objective astigmatism analysis. Moreover, understanding incision-related refractive outcomes is particularly relevant in high-volume tertiary care centers, where early uncorrected visual recovery is a key determinant of surgical success.

Therefore, the present study was undertaken to prospectively compare straight, frown and chevron incisions in manual small-incision cataract surgery with respect to postoperative visual acuity and SIA. By evaluating refractive stability and visual outcomes at six weeks postoperatively, this study aims to provide evidence-based guidance on incision selection to optimize outcomes in routine cataract surgery practice in resource-constrained settings.

Materials and methods

This prospective observational analytical study was conducted in the Department of Ophthalmology, Chittagong Medical College Hospital, Chattogram, Bangladesh, from February 2022 to January 2023.

Patients aged 40 years with uncomplicated age-related cataract (Nuclear sclerosis grade 1–4) and with-the-rule astigmatism scheduled for manual Small-Incision Cataract Surgery (SICS) were enrolled. Patients with complicated cataract, pre-existing corneal or retinal disease, other ocular pathology or unwillingness to participate were excluded.

The sample size was calculated to detect differences in SIA (SIA) with 80% power and a 5% significance level. A total of 110 patients were included and allocated to straight (n=37) frown (n=49) or chevron (n=24) incision groups.

Consecutive eligible patients underwent standardized preoperative evaluation, including visual acuity assessment, slit-lamp examination, applanation tonometry, fundoscopy, automated keratometry and intraocular lens power calculation using A-scan biometry (SRK-II formula). All surgeries were performed by a single experienced surgeon under peribulbar anesthesia, with identical surgical steps except for incision configuration. A self-sealing sclero-corneal tunnel was created, continuous curvilinear capsulorrhexis completed, the nucleus delivered using an irrigating vectis and a single-piece PMMA intraocular lens implanted in the capsular bag. All wounds were left sutureless.

Postoperative examinations were conducted on day 1 and at 6 weeks. Outcome measures included uncorrected and best-corrected visual acuity, keratometric astigmatism and SIA, calculated at 6 weeks using SIA Calculator version 2.1.

Data were analyzed using SPSS version 25.0. Categorical variables were expressed as frequencies and percentages and compared using the Chi-square test. Continuous variables were presented as mean ± standard deviation. Differences in mean astigmatism and SIA among incision groups were analyzed using one-way ANOVA, followed by Games–Howell post-hoc testing. A p-value <0.05 was considered statistically significant.

Ethical approval was obtained from the Ethical Review Committee of Chittagong Medical College (Memo no. CMC/PG/2022/817, Dated: 08/02/2022). Written informed consent was obtained from all participants, confidentiality was strictly maintained, and the study adhered to the principles of the Declaration of Helsinki.

Results

A sum of 110 patients with age related senile cataracts were added in the study and followed up for a period of 6 weeks after manual SICS. The

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results and observations of the present study are presented in the following Tables and Graphs.

Table I Baseline demographic characteristics according to incision type

Variable		Straight (n=37)	Frown (n=49)	Chevron (n=24)	p value
Age (Years)	mean ± SD	60.4 ± 10.1	62.8 ± 12.1	60.7 ± 10.4	0.533*
Gender	Male, n (%)	21 (56.8)	23 (46.9)	9 (37.5)	0.330†
	Female, n (%)	16 (43.2)	26 (53.1)	15 (62.5)	

The mean age of all patients was 61±11.33 years. Data were expressed as either mean ±SD or frequency (Percentage) *F- test in ANOVA, †Chi-square test.

The baseline demographic characteristics were comparable among the three incision groups. The overall mean age of participants was 61 ± 11.33 years, with no statistically significant difference between straight, frown and chevron incision groups (p = 0.533). Gender distribution also did not differ significantly among groups (p = 0.330)

Table II Preoperative visual acuity and corneal astigmatism

Parameter		Straight (n=37)	Frown (n=49)	Chevron (n=24)	p value
UCVA n (%)	<3/60–PL+,	30 (81.1)	37 (75.5)	19 (79.2)	0.905†
	<6/60–3/60	3 (8.1)	4 (8.1)	1 (4.1)	
	<6/18–6/60	4 (10.8)	8 (16.4)	4 (16.7)	
BCVA n (%)	<3/60–PL+,	28 (75.7)	31 (63.3)	13 (54.2)	0.205†
	<6/18–6/60	9 (24.3)	18 (36.7)	11 (45.8)	
Pre-op astigmatism (D)	mean ± SD	0.83 ± 0.61	0.63 ± 0.43	0.69 ± 0.54	0.220*

Data were expressed as either mean ±SD or frequency (percentage) *F- test in ANOVA, †Chi-square test. BCVA: Best corrected visual acuity, PL: Perception of Light, UCVA: Uncorrected visual acuity.

There were no statistically significant differences between the groups regarding preoperative Uncorrected Visual Acuity (UCVA) (p=0.905) or Best Corrected Visual Acuity (BCVA) (p=0.205). Preoperative mean astigmatism was similar across groups: Straight (0.83±0.61 D) Frown (0.63±0.43 D) and Chevron (0.69±0.54 D) with P=0.220.

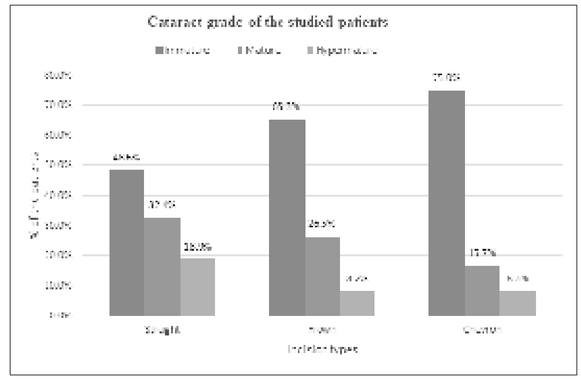

Figure 1 Distribution of cataract grades among incision groups

Figure 1 shows that immature cataracts were most frequent in the Chevron (75.0%) and Frown (65.3%) groups, whereas the Straight group handled a higher proportion of mature (32.4%) and hypermature (18.9%) cases.

Table III Comparison of postoperative visual acuity between incision groups

Time point	Outcome	Straight (n=37)	Frown (n=49)	Chevron (n=24)	p value
UCVA (Day 1)	<6/18-6/60	32 (86.5)	40 (81.6)	15 (62.5)	0.025
	6/6-6/18	5 (13.5)	9 (18.4)	9 (37.5)	
BCVA (Day 1)	<6/18-6/60	17 (45.9)	16 (32.7)	8 (33.3)	0.407
	6/6-6/18	20 (54.1)	33 (67.3)	16 (66.7)	
UCVA (6 weeks)	≤6/18-6/60	9 (24.3)	4 (8.1)	2 (8.3)	0.034
	6/6-6/18	28 (74.7)	45 (91.9)	22 (91.7)	
BCVA (6 weeks)	≤6/18-6/60	0 (0)	1 (2.0)	0 (0)	0.391
	6/6-6/18	37 (100.0)	48 (98.0)	24 (100.0)	

Data were expressed as frequency (Percentage) p value derived from Chi-square test. BCVA: Best corrected visual acuity, UCVA: Uncorrected visual acuity.

On postoperative day 1, uncorrected visual acuity differed significantly among incision groups (p = 0.025) with the chevron incision group demonstrating a higher proportion of patients achieving UCVA 6/6–6/18. At 6 weeks, this difference remained significant (p = 0.034) with both frown and chevron incisions yielding superior UCVA compared to straight incisions.

Best-corrected visual acuity at 6 weeks was excellent across all groups, with nearly all patients achieving BCVA ≥6/18, and no statistically significant intergroup difference (p = 0.391).

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Table IV Distribution of Surgically Induced Astigmatism (SIA) at 6 weeks

SIA category	Straight (n=37)	Frown (n=49)	Chevron (n=24)	p value
0.25–0.50 D	0 (0)	32 (65.3)	17 (70.8)	<0.001
0.75–1.00 D	33 (89.2)	16 (32.7)	7 (29.2)	
>1.0 D	4 (10.8)	1 (2.0)	0 (0)	

Data were expressed as frequency (Percentage) †Chi-square test.

There was a highly significant difference in SIA distribution ($p < 0.001$). While 89.2% of Straight incision patients fell into the 0.75–1.00 D category, the majority of Frown (65.3%) and Chevron (70.8%) patients were in the lower 0.25–0.50 D category.

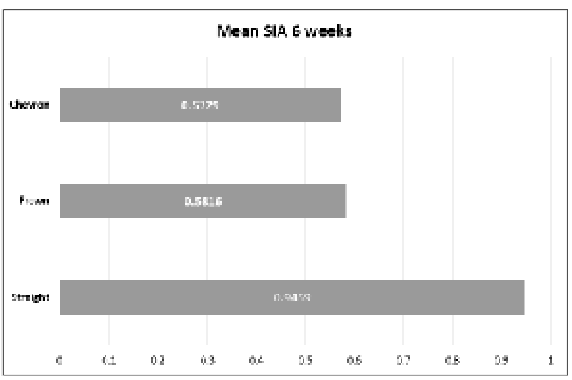

Figure 2 Mean SIA at 6 weeks

Mean SIA was highest in the straight incision group (0.95 D) while significantly lower and comparable values were observed in frown (0.58 D) and chevron (0.57 D) incision groups.

Discussion

SIA is one of the key factors in determining the postoperative outcome and patient satisfaction because uncorrected visual acuity is dependent on surgical-induced astigmatism. The scleral incision and self-sealing sclera-corneal tunnel were introduced in the early eighties in manual SICS to provide better wound healing with less surgical-induced astigmatism. The scleral incision in manual SICS is considered one of the important factors in determining surgical-induced astigmatism. The present study compares the outcome of manual SICS in terms of SIA and visual acuity after 6 weeks postoperatively in 110 patients with senile cataracts in a tertiary-level hospital at Chattogram in Bangladesh. The study demonstrated that, 6 weeks following manual SICS excellent best corrected visual acuity was attained by all three incision-straight, frown, and chevron. However, Chevron and frown incision induces less astigmatism compared to straight incision.

The baseline demographic analysis revealed a mean patient age of 61±11.33 years with no significant differences in age (p=0.533) across the three group. The mean age of the patients in the study was higher than the study of Yadav et al. (57.9 years) but lower than the study of Rathi et al. (66.22 years).[8,9] In present study, the mean age was around 61 years, which is typical for cataract surgery cohorts and falls within the range where most patients achieve good visual outcomes. This similarity in age distribution across groups ensures that age does not bias the comparison of incision types. In the present study, no statistically significant difference in sex distribution was observed among the straight, frown, and chevron incision groups (p=0.330), indicating that sex did not act as a confounding variable in the comparison of postoperative outcomes. This balanced distribution allows a more reliable interpretation of visual acuity and SIA as being primarily influenced by incision design rather than patient sex. There is almost no difference in surgical complication rates or final visual outcomes between sexes in previous study.[10] Overall, the absence of a significant sex-based effect on surgical outcomes supports the generalizability of the study findings to both male and female patients undergoing manual small-incision cataract surgery.

Most patients presented with poor preoperative visual acuity, with over 75% having UCVA worse than 3/60 in all groups. Preoperative BCVA distribution was similar among incision types (p = 0.205). This was consistence with the results of the previous study where out of 120 patients overall 72% of the patients presented with best corrected visual acuity less than 6/60 preoperatively.[8] However, a study by Desai et al. performed in the United Kingdom showed that 84% of patients prepared for cataract surgery had VA more than 6/60 (31% better than 6/12).[11] This dissimilarity in the preoperative visual acuity may be due to the late presentation of cataracts in our setup which may because of poverty, illiteracy and lack of information about the curative nature of the disease.

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Immature cataract was the most common type across all incision groups. A relatively higher proportion of mature and hypermature cataracts was observed in the straight incision group compared to the frown and chevron groups. It was observed that 100% of the patients in the straight and chevron incision group and 98% of patients in the frown incision group attained the best corrected visual acuity of at least 6/18 or better at six weeks post-operatively. Only one patient had BCVA <6/18. Similar results were seen in previous studies who compared surgical-induced astigmatism in various incisions in manual SICS.[7-9] Rathi et al. found that 97%, 97% and 93% of patients attained the best corrected visual acuity of at least 6/18 or better at 12 weeks postoperatively in chevron, straight and frown incision groups, respectively.[9] Jauhari et al. found that 89.5% of patients in the straight incision group, 94.2% in the frown incision group and 95.7% in the inverted V group attained the best corrected visual acuity post-operatively in the range of 6/6 to 6/18.[7] Results of the present study and the previous studies indicated that all the incision types had good visual outcomes at 6 weeks postoperatively. In the study of Yadav et al. at 6 weeks uncorrected visual acuity of 6/18-6/6 was attained by 63.41%, 78.94% and 84.61% of patients in groups straight, frown and chevron. However, about 97% of patients attained the best corrected visual acuity of 6/18-6/6 in all three groups.[8]

SIA remains one of the hindrances in achieving excellent uncorrected visual acuity, which is the main aim of cataract surgery and the primary requirement of the patient. In the present study, SIA was calculated in every case using the SIA Calculator version 2.1, a free software program by Saurabh and Ashima.[12] In the current study, Mean SIA was lowest for the Chevron group (0.5729 D) followed by Frown (0.5816 D) and highest for Straight (0.9459 D). The minimum amount of SIA was seen with the chevron type of incision and the maximum with straight incision. The present study results confirmed the previous research results which reported that SIA is highest with the straight type and lowest with the chevron incision type.[7-9] In the study of Rathi et al. induced astigmatism in chevron incision was 0.34D ± 0.22D, in straight incision was 0.97D ± 0.29D, and in frown incision was 0.575D ± 0.25D.(9) The mean Surgical induced astigmatism was found to be -1.08 ± 0.67D, -0.960.±71D and -0.88 ± 0.61D, respectively, at four weeks post-operatively in the study of Jauhari et al.[7] Yadav et al. found that mean Surgical induced astigmatism was least in the Chevron group (0.30 D ± 0.16) and was most in the straight group (1.22 D ±0.36) which was statistically significant.[8]

In the present study, 70.8% of patients had SIA between 0.25 and 0.50D and none had induced astigmatism >1.0D in the chevron incision group. In the frown group, 65.3% and 32.7% of patients had induced astigmatism between 0.25-0.50 and 0.75-1.0D, respectively and one had induced astigmatism >1.0D. In the straight incision group, 89.2% of patients had induced astigmatism between 0.75-1.0D and 10.8% had induced astigmatism >1.0D. Rathi et al. found that 70% of patients had induced astigmatism between 0.25 and 0.50D and none had induced astigmatism >1D in the chevron group. In straight incisions 73% of patients had induced astigmatism between 0.75 and 1D and 20% had induced astigmatism >1D. In the frown incision group, 63% of patients had induced astigmatism between 0.25 and 0.50D and none had induced astigmatism >2D.(9) Patra et al. found that chevron incisions produced minimum astigmatism with maximum patients (48%) with astigmatism between 0.5 and 1D followed by 36% in 0.6–1D. In frown incision, maximum patients (44%) had astigmatism 1.1–1.5D followed by (28%) 0.5– 1D. Straight incisions showed significantly higher astigmatism with maximum patients (40%) between 1.1 and 1.5D, only 28% of straight incision patients had astigmatism <1D while 24% showed astigmatism 1.5–2D.[13] Moreover, the study finding of Yadav et al. suggested that chevron incision achieved the astigmatic stability much earlier than the other group as net change in mean surgical induced astigmatism in 2 weeks and 6 weeks is only 0.03 D in chevron group as compared to 0.17 D in straight group and 0.8 D in frown group.[8]

The curved configuration of frown and chevron incisions likely distributes biomechanical stress more evenly, reducing corneal flattening along the incision meridian. The marginally lower mean

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SIA observed with chevron incisions suggests a potential refractive advantage, although both non-linear techniques performed similarly. Overall, these findings support the preferential use of frown or chevron incisions in manual SICS to optimize refractive stability and enhance early uncorrected visual recovery, particularly in high-volume settings where rapid visual rehabilitation is desirable.

Limitations

This was a single-center study with a relatively small sample size and short follow-up period of six weeks, which may limit the generalizability of the findings and assessment of long-term refractive stability. Surgeries were performed by a single surgeon, and only patients with with-the-rule astigmatism were included, which may restrict broader applicability.

Conclusion

Based on the study findings it can be concluded that SIA by frown and chevron incision in manual SICS is the minimum, followed by straight incision. Though all the incision types had good visual outcomes at 6 weeks postoperatively after spectacle correction.

Recommendations

Frown and chevron incisions are recommended in manual small-incision cataract surgery to reduce surgically induced astigmatism and achieve better early uncorrected visual outcomes. Larger multicenter studies with longer follow-up and inclusion of different astigmatic patterns are recommended to further validate these findings.

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Contribution of authors

MU-Conception, acquisition of data, data analysis, drafting & final approval.

RI-Data analysis, critical revision & final approval.

TT-Design, interpretation of data, critiical revision & final approval.

MH-Interpretation of data, critical revision & final approval.

NER-Data analysis, drafting & final approval.

SFTF-Data analysis, interpretation of data, drafting & final approval.

Disclosure

All the authors declared no conflict of interest.

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