

COMPARATIVE EVALUATION OF SURGICALLY INDUCED ASTIGMATISM AND VISUAL OUTCOMES IN ELDERLY PATIENTS UNDERGOING MANUAL SMALL INCISION CATARACT SURGERY: SUPERIOR STRAIGHT VERSUS SUPERIOR FROWN INCISION

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Received : 04/01/2026
Received in revised form : 26/02/2026
Accepted : 14/03/2026

Keywords:

Manual small incision cataract surgery, surgically induced astigmatism, straight incision, frown incision, keratometry, refractive outcome.

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DOI: 10.47009/jamp.2026.8.2.87

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2026; 8 (2); 476-480



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ABSTRACT

Background: Manual small incision cataract surgery (MSICS) remains the preferred technique in many tertiary care centres across India due to its cost-effectiveness and applicability in dense cataracts. However, surgically induced astigmatism (SIA) continues to be a significant determinant of postoperative visual quality. The configuration and size of the scleral incision are known to influence corneal curvature changes and refractive outcomes. **Aim:** To compare the magnitude of surgically induced astigmatism following a 7 mm superior straight incision and a 6 mm superior frown incision in MSICS. **Materials and Methods:** This prospective interventional study included 120 eyes of 120 patients with senile cataract undergoing MSICS at a tertiary care centre in India. Patients were randomly allocated into two equal groups: Group A (n=60) underwent MSICS with a 7 mm superior straight scleral incision, and Group B (n=60) underwent MSICS with a 6 mm superior frown incision. Keratometric readings were recorded preoperatively and at 6 weeks postoperatively. SIA was calculated using vector analysis. Uncorrected visual acuity (UCVA) and best corrected visual acuity (BCVA) were assessed at 6 weeks. Statistical analysis was performed using unpaired t-test and chi-square test, with p<0.05 considered significant. **Results:** The mean SIA at 6 weeks was significantly higher in Group A (1.94 ± 0.38 D) compared to Group B (0.79 ± 0.27 D) (p<0.001). A greater proportion of patients in the frown incision group achieved UCVA ≥6/18 (88.3%) compared to the straight incision group (61.7%). BCVA of 6/9 or better was achieved in 93.3% of Group B compared to 81.7% in Group A. Superior straight incisions predominantly induced against-the-rule astigmatism. **Conclusion:** A 6 mm superior frown incision produces significantly lower surgically induced astigmatism compared to a 7 mm superior straight incision in MSICS. Adoption of frown incision technique in tertiary and high-volume centres may improve refractive outcomes and reduce postoperative spectacle dependence.

INTRODUCTION

Cataract remains the leading cause of reversible blindness worldwide, accounting for nearly half of global blindness burden, particularly in developing countries such as India. With increasing life expectancy and expanding cataract surgical coverage, optimizing visual and refractive outcomes has become an essential component of modern cataract surgery.¹

Manual small incision cataract surgery (MSICS) is widely practiced in India due to its low cost, shorter surgical time, and effectiveness in managing advanced or hard cataracts. Although phacoemulsification offers smaller incisions and faster refractive stabilization, MSICS continues to be the mainstay in high-volume tertiary and rural centres where affordability and accessibility are critical.² One of the principal limitations of MSICS is surgically induced astigmatism (SIA). SIA results

from biomechanical alterations in corneal curvature following scleral tunnel construction. An incision causes flattening along the meridian of placement and compensatory steepening in the perpendicular meridian, thereby altering corneal astigmatism. The magnitude of SIA depends on several factors including incision size, shape, depth, location, and wound architecture.^{3,4}

Superior incisions, commonly used in MSICS, are known to induce against-the-rule (ATR) astigmatism due to vertical meridian flattening. Previous studies have demonstrated that larger and straight incisions are associated with higher SIA compared to smaller or curved incisions⁵. Singer first described the frown incision as a modification designed to distribute wound stress more evenly and reduce corneal flattening, thereby minimizing postoperative astigmatism.⁶

Modifying incision architecture in MSICS can significantly reduce postoperative astigmatism without increasing surgical complexity.⁷ Incision configuration plays a crucial role in determining refractive stability. Given that a substantial proportion of Indian patients present with pre-existing corneal astigmatism between 0.75 and 2.00 D, tailoring incision design may serve as a practical method for optimizing refractive outcomes without additional cost.

Despite multiple comparative studies, data from large prospective cohorts in Indian tertiary care settings remain limited.⁸

The present study was therefore undertaken to evaluate and compare surgically induced astigmatism following superior straight and superior frown incisions in MSICS in a sample of 120 patients.

MATERIALS AND METHODS

This prospective, randomized, interventional comparative study was conducted at a tertiary care teaching hospital in India over a period of 24 months. The study adhered to the tenets of the Declaration of Helsinki. Institutional Ethics Committee approval was obtained prior to commencement of the study, and written informed consent was taken from all participants.

Based on previous studies showing a mean difference of approximately 1.0 D in SIA between straight and frown incisions with standard deviations of 0.4–0.5 D, and assuming 80% power and 5% level of significance, the minimum calculated sample size was 50 eyes per group. To improve statistical robustness and compensate for potential loss to follow-up, 60 eyes were included in each group, resulting in a total sample size of 120 eyes of 120 patients.

Inclusion Criteria

- Patients aged ≥ 40 years diagnosed with senile cataract
- Clear cornea with measurable keratometry readings

- Willingness to comply with follow-up schedule

Exclusion Criteria

- Traumatic, congenital, or complicated cataract
- Pre-existing corneal pathology (opacity, degeneration, dystrophy)
- Glaucoma or retinal pathology affecting visual outcome
- Previous ocular surgery
- Intraoperative or significant postoperative complications

Randomization and Group Allocation

A total of 120 patients were randomly allocated into two equal groups (n=60 each) using computer-generated random numbers:

Group A: MSICS with 7 mm superior straight scleral incision

Group B: MSICS with 6 mm superior frown scleral incision

All surgeries were performed by a single experienced surgeon to eliminate inter-surgeon variability.

Preoperative Evaluation

All patients underwent detailed ophthalmic examination including:

- Uncorrected visual acuity (UCVA)
- Best corrected visual acuity (BCVA)
- Slit-lamp biomicroscopy
- Intraocular pressure measurement by applanation tonometry
- Lacrimal sac syringing
- Dilated fundus examination

Keratometry readings were obtained using an automated keratometer (Topcon RK 8800). IOL power was calculated using A-scan biometry (SRK-II formula).

Surgical Technique

All cases were performed under peribulbar anesthesia using 2% lignocaine with hyaluronidase. A fornix-based conjunctival flap was created superiorly. In Group A, a 7 mm straight scleral incision was made 1.5–2 mm posterior to the limbus. In Group B, a 6 mm frown-shaped scleral incision was constructed at the same location with curved architecture.

A self-sealing sclero-corneal tunnel was fashioned using a crescent blade extending 1.5 mm into clear cornea. A side-port incision was made at 9 o'clock. Continuous curvilinear capsulorrhexis, hydrodissection, nucleus delivery by viscoexpression, cortical aspiration, and implantation of a rigid PMMA posterior chamber intraocular lens were performed in all cases.

No sutures were placed in any case.

Postoperative Regimen and Follow-up

Topical antibiotic-steroid combination drops were prescribed for 6 weeks in tapering doses. Follow-up examinations were conducted at 1 week and 6 weeks postoperatively. Keratometry readings, UCVA, and BCVA were recorded at each visit.

Outcome Measures

Primary Outcome

- Surgically induced astigmatism (SIA) at 6 weeks

Secondary Outcomes

- Postoperative UCVA at 6 weeks
- Postoperative BCVA at 6 weeks
- Type of postoperative astigmatism (WTR/ATR)

SIA was calculated using vector analysis comparing preoperative and postoperative keratometric readings. Data were analyzed using SPSS version 22. Continuous variables were expressed as mean \pm standard deviation. Categorical variables were expressed as percentages. Unpaired t-test was used to compare mean SIA between groups. Chi-square test was applied for categorical comparisons. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 120 elderly patients (120 eyes) were analyzed, with 60 patients in each group. The mean age was comparable between Group A (62.1 ± 8.5 years) and Group B (63.4 ± 9.1 years) ($p=0.41$). Gender distribution was also similar across groups ($p=0.71$), ensuring baseline comparability.

At 6 weeks postoperatively, surgically induced astigmatism (SIA) was significantly greater in the

superior straight incision group compared to the superior frown incision group. The mean SIA in Group A was 1.94 ± 0.38 diopters, whereas in Group B it was 0.79 ± 0.27 diopters ($t=18.62$, $p<0.001$), indicating a highly significant reduction in astigmatism with the frown incision technique.

Postoperative uncorrected visual acuity (UCVA) showed marked intergroup differences. Functional vision (UCVA $\geq 6/18$) was achieved in 37 patients (61.7%) in Group A compared to 53 patients (88.3%) in Group B ($\chi^2=11.84$, $p=0.0006$). Furthermore, 53.3% of patients in the frown incision group achieved UCVA of 6/6–6/9 compared to only 23.3% in the straight incision group. Mean postoperative UCVA in logMAR units was significantly better in Group B (0.18 ± 0.14) than in Group A (0.36 ± 0.21) ($t=5.46$, $p<0.001$).

Best corrected visual acuity (BCVA), however, was comparable between groups. BCVA of 6/6–6/9 was achieved in 81.7% of patients in the straight incision group and 93.3% in the frown incision group, with no statistically significant difference ($p=0.12$). These findings suggest that while both techniques effectively restored maximal visual potential, incision configuration significantly influenced refractive and unaided visual outcomes.

Demographic Profile

Table 1: Age distribution

	Group A (7mm straight) n=60	Group B (6mm frown) n=60	Test Value	p-value
Mean Age (years)	62.1 ± 8.5	63.4 ± 9.1	$t = 0.82$	0.41

Mean age was comparable between Group A (62.1 ± 8.5 years) and Group B (63.4 ± 9.1 years) ($p=0.41$).

Table 2: Gender Distribution

	Group A (7mm straight) n=60	Group B (6mm frown) n=60	Test Value	p-value
Male:Female	31 : 29	33 : 27	$t = 0.13$	0.71

Gender distribution was compared in Group A and Group B.

Table 3: Preoperative Astigmatism Distribution

Type of Astigmatism	Group A (7mm straight) n=60	Group B (6mm frown) n=60	Test Value	p-value
With the rule (WTR)	32(53.3%)	33 (55%)	$t = 0.05$	0.82
Against the rule (ATR)	23(38.3%)	24(40%)		
Oblique	5(8.3%)	3(5%)		

Preoperative type of astigmatism compared between group A and Group B.

Table 4: Postoperative Keratometric Astigmatism at 6 Weeks

	Group A (7mm straight) (Mean \pm SD)	Group B (6mm frown) (Mean \pm SD)	Test Value	p-value
Mean post operative Astigmatism(D)	2.48 ± 0.96	1.88 ± 0.64	4.07	<0.001

Mean post operative astigmatism compared between group A and Group B.

Table 5: Surgically Induced Astigmatism

	Group A (7mm straight) (Mean \pm SD)	Group B (6mm frown) (Mean \pm SD)	Test Value	p-value
Mean Surgical Induced Astigmatism(D)	1.94 ± 0.38	0.79 ± 0.27	18.62	<0.001

The mean SIA in Group A was 1.94 ± 0.38 diopters, whereas in Group B it was 0.79 ± 0.27 diopters.

Table 6: Postoperative Bestcorrected Visual Acuity (6/9-6/6)

	Group A (7mm straight)	Group B (6mm frown)	Test Value χ^2	p-value
Postoperative Uncorrected Visual Acuity	81.7%	93.3%	11.84	<0.12

BCVA of 6/6–6/9 was achieved in 81.7% of patients in the straight incision group and 93.3% in the frown incision group, with no statistically significant difference.

DISCUSSION

Visual rehabilitation in elderly patients extends beyond restoration of clarity; it directly influences mobility, independence, and overall quality of life. In geriatric populations, even small residual refractive errors may compromise functional vision, increase risk of falls, and reduce confidence in daily activities. Therefore, minimizing surgically induced astigmatism (SIA) during cataract surgery is of particular importance in this age group.^[7]

In our study, mean SIA in the superior straight incision group (1.94 ± 0.38 D) was significantly higher than in the superior frown incision group (0.79 ± 0.27 D). Our findings were similar to Gokhale and Sawhney study that the curved scleral incisions significantly reduce postoperative astigmatism compared to straight incisions, attributing this to better distribution of wound tension.^[7]

In our study Mean SIA of (1.94 ± 0.38 D) observed in the straight incision group were comparable to study reported by Malik et al. which was approximately 1.5 D -1.^[8] D .In contrast ,curved incisions such as frown or chevron were associated with lower postoperative astigmatism.^[8]

The magnitude of SIA observed in our straight incision group were similar to results reported by Reddy et al who found mean SIA values approaching 1.8–2.0 D with superior linear incisions.^[9]

A key clinical implication of reduced SIA was the significantly better uncorrected visual acuity (UCVA) in the frown incision group. In our study, 88.3% of patients in the frown group achieved UCVA $\geq 6/18$ compared to 61.7% in the straight incision group our findings were similar to results reported by Pankaj kumar study. Refractive outcomes are increasingly important in high-volume cataract programs in India, as postoperative spectacle compliance may be inconsistent, particularly in rural and elderly populations.^[10] Improved unaided vision reduces dependency on corrective lenses and facilitates early return to routine activities.

Despite differences in UCVA, best corrected visual acuity (BCVA) was comparable between groups, indicating that both techniques are equally effective in restoring maximal visual potential. This observation aligns with prior studies suggesting that incision configuration primarily affects refractive outcome rather than surgical safety or final corrected vision.^[8,10]

Collier Wakefield and Annoth studied the relation between corneal astigmatism and ocular parameters in cataract surgery patients .Their findings highlights the importance of minimizing SIA in order to avoid the overall refractive error after cataract extraction .In our study the lower the magnitude of Mean SIA observed in Frown Incision for better functional vision in this patients.^[11]

Overall the results of the present study clearly demonstrates that incision configuration plays a critical role in determining refractive outcomes following MSICS. The 7 mm superior straight incision produces significantly higher SIA and comparatively poor uncorrected visual acuity whereas 6mm superior frown incision resulted in markedly lower astigmatism and better functional outcome.

The curved incision distributes wound tension more evenly along the scleral tunnel, reduces wound gape and minimises corneal curvature changes.

Consequently, the patients undergoing MSICS with frown incision achieve better unaided visual acuity and faster visual rehabilitation

CONCLUSION

Among geriatric patients undergoing manual small incision cataract surgery, superior frown incision produces significantly lower surgically induced astigmatism and better uncorrected visual acuity compared to superior straight incision. Adoption of frown incision technique may enhance functional visual independence and quality of life in elderly populations.

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