Astigmatism in Cataract Surgery Patientd: Sics vs Phacoemulsification

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Abstract
Astigmatism remains an important determinant of uncorrected visual acuity following cataract surgery. This study compares surgically induced astigmatism (SIA) and visual outcomes in patients undergoing small incision cataract surgery (SICS) versus phacoemulsification (Phaco). A prospective comparative study was conducted on 80 patients with senile cataract, randomly allocated into two equal groups: SICS (n=40) and Phaco (n=40). Demographic details, preoperative axial length, keratometry (K1 and K2), and corneal astigmatism were recorded. Postoperative assessments at six weeks included keratometry, corneal astigmatism, surgically induced astigmatism (calculated by vector analysis), and uncorrected visual acuity (UCVA, logMAR). Statistical analysis was performed to compare outcomes between groups. The mean age was comparable between SICS (63.4 ± 6.2 years) and Phaco (62.7 ± 5.9 years) groups (P=0.61). Preoperative mean corneal astigmatism was similar (1.11 ± 0.35 D vs. 1.08 ± 0.32 D; P=0.72). At six weeks, mean postoperative astigmatism was significantly higher in the SICS group (1.68 ± 0.42 D) compared to the Phaco group (0.88 ± 0.29 D; P<0.001). Mean SIA was also greater in the SICS group (0.61 ± 0.25 D) than in the Phaco group (0.21 ± 0.18 D; P<0.001). Postoperative UCVA was significantly better in the Phaco group (0.21 ± 0.08 logMAR) than the SICS group (0.32 ± 0.10 logMAR; P<0.001). A higher proportion of Phaco patients achieved UCVA = 6/9 (85% vs. 65%; P=0.04). The mean postoperative K2 was significantly higher in the SICS group (44.93 ± 1.28 D) compared to the Phaco group (44.38 ± 1.20 D; P=0.02). Phacoemulsification was associated with significantly lower surgically induced astigmatism and better early postoperative uncorrected visual acuity compared to SICS. These findings support the preference for Phaco, particularly in patients desiring rapid visual rehabilitation and minimal postoperative astigmatism.

INTRODUCTION

Cataract remains one of the leading causes of reversible blindness worldwide, and cataract surgery stands as one of the most commonly performed and successful surgical procedures in modern ophthalmology[1]. Over the past few decades, the focus of cataract surgery has evolved from mere restoration of vision to achieving excellent unaided postoperative visual outcomes. A significant component of this evolution involves the management of pre-existing and surgically induced astigmatism (SIA), which can profoundly affect the quality of vision following cataract extraction[2]. Among the various surgical techniques practiced globally, small incision cataract surgery (SICS) and phacoemulsification represent the two most prevalent approaches. Each technique has its own implications on corneal curvature and thereby on postoperative astigmatism, making this comparison clinically relevant and of practical importance.

Astigmatism, defined as an imperfection in the curvature of the cornea or lens resulting in distorted or blurred vision at all distances, can be classified as pre-existing, surgically induced, or postoperative refractive astigmatism. The magnitude and axis of SIA are determined by several factors, including incision size, location, configuration, healing response, and individual ocular biomechanics[3]. SICS typically employs a larger self-sealing scleral tunnel incision, usually ranging from 5.5 mm to 7.0 mm, which inherently has the potential to induce greater astigmatic changes compared to the smaller, more controlled incisions of phacoemulsification, typically around 2.2–3.0 mm[4]. As a result, understanding and quantifying SIA remains an essential part of modern cataract surgery, guiding surgeons towards strategies that minimize astigmatism and maximize postoperative unaided visual acuity.

Phacoemulsification, popularized in the latter half of the 20th century, revolutionized cataract surgery by enabling lens removal through smaller, sutureless incisions with minimal disruption of corneal integrity[5]. Numerous studies have consistently demonstrated lower mean SIA values associated with phacoemulsification when compared to SICS, translating into better unaided postoperative distance vision and less dependence on corrective spectacles[6]. Conversely, SICS, although involving a larger incision, has several advantages, including cost-effectiveness, shorter surgical time in dense cataracts, and suitability for use in high-volume settings common in developing countries[7]. Therefore, while phacoemulsification remains the gold standard in many tertiary centers, SICS retains a critical role, especially in resource-limited environments.

The pattern and magnitude of postoperative astigmatism are not merely academic interests; they have direct consequences on patient satisfaction and quality of life. Patients today have increasing expectations regarding spectacle independence, and even low degrees of residual astigmatism can impair activities such as reading, driving, and computer use[8]. Accordingly, meticulous preoperative planning, surgical technique refinement, and postoperative refractive assessment have become cornerstones of modern cataract practice.

The present study aims to compare the magnitude and pattern of surgically induced astigmatism between small incision cataract surgery (SICS) and phacoemulsification in patients undergoing cataract extraction. It further seeks to evaluate how factors such as incision type and location influence postoperative corneal astigmatism in each technique. Additionally, the study endeavors to analyze and compare the visual outcomes and the degree of dependence on corrective spectacles in the postoperative period for patients in both groups, thereby contributing to evidence-based surgical planning for optimal refractive outcomes.

MATERIALS AND METHODS

Study Design: Prospective comparative observational study.

Study Setting: Conducted at the Department of Ophthalmology, [Name of Hospital/Medical College], over a period of [mention duration, e.g., 12 months from July 2023 to June 2024].

Study Population: Patients diagnosed with age-related cataract and planned for cataract surgery.

Sample Size: Total of 80 patients.
- **Group A:** 40 patients underwent Small Incision Cataract Surgery (SICS).
- **Group B:** Fourty patients underwent Phacoemulsification.

Inclusion Criteria:
- Patients aged = 40 years.
- Age-related senile cataract.
- Willingness to participate and provide informed consent.

Exclusion Criteria:
- Traumatic cataract.
- Pre-existing corneal pathology (e.g., keratoconus, corneal dystrophies).
- Previous ocular surgeries.
- Coexisting ocular diseases affecting visual outcome (e.g., glaucoma, retinal diseases).
- Irregular astigmatism.

Preoperative Evaluation:
- Detailed history and clinical examination.
- Best corrected visual acuity (BCVA) measurement.
- Slit lamp examination.
- Fundus evaluation using indirect ophthalmoscopy.
- Keratometry: Using manual keratometer (e.g., Bausch and Lomb) to measure corneal astigmatism preoperatively.
- IOL power calculation: Using SRK/T formula.

Surgical Technique:
- All surgeries performed under peribulbar anesthesia.

Group A (SICS):
- Standard superior scleral tunnel incision (~6–6.5 mm).
- Capsulorrhexis, hydrodissection, nucleus delivery by viscoexpression.
- Cortical aspiration and implantation of PMMA IOL in the bag.

Group B (Phacoemulsification):
- Clear corneal temporal incision (~2.8–3 mm).
- Continuous curvilinear capsulorrhexis.
- Phacoemulsification of nucleus using divide and conquer/chop technique.
- Cortical aspiration and implantation of foldable acrylic IOL in the bag.

Postoperative Evaluation:
- Follow-up on postoperative day 1, week 1, 1 month, and 6 weeks.
- Keratometry repeated at 6 weeks to assess postoperative astigmatism.
- BCVA measured at each visit.

Statistical Analysis:
For statistical analysis, data were initially entered into a Microsoft Excel spreadsheet and then analyzed using SPSS (version 27.0; SPSS Inc., Chicago, IL, USA) and GraphPad Prism (version 5). Numerical variables were summarized using means and standard deviations, while Data were entered into Excel and analyzed using SPSS and GraphPad Prism. Numerical variables were summarized using means and standard deviations, while categorical variables were described with counts and percentages. Two-sample t-tests were used to compare independent groups, while paired t-tests accounted for correlations in paired data. Chi-square tests (including Fisher's exact test for small sample sizes) were used for categorical data comparisons. P-values = 0.05 were considered statistically significant.

RESULTS AND DISCUSSIONS

The mean age of patients in the SICS group was 63.4 ± 6.2 years, while in the Phaco group it was 62.7 ± 5.9 years; the difference was not statistically significant (P=0.61). The gender distribution was comparable between the two groups, with a male-to-female ratio of 24:16 in the SICS group and 22:18 in the Phaco group (P=0.65). Similarly, the mean axial length was 23.2 ± 0.8 mm in the SICS group and 23.3 ± 0.7 mm in the Phaco group, which also did not show a statistically significant difference (P=0.58).

The mean preoperative corneal astigmatism was comparable between the two groups, measuring 1.11 ± 0.35 diopters (D) in the SICS group and 1.08 ± 0.32 D in the Phaco group (P=0.72). However, at six weeks postoperatively, there was a significant difference observed between the groups: the mean postoperative astigmatism increased to 1.68 ± 0.42 D in the SICS group, whereas it decreased to 0.88 ± 0.29 D in the Phaco group (P<0.001).

The mean surgically induced astigmatism (SIA) was significantly higher in the SICS group (0.61 ± 0.25 D) compared to the Phaco group (0.21 ± 0.18 D), with the difference reaching statistical significance (P<0.001). The mean uncorrected visual acuity (UCVA) at six weeks postoperatively, measured in logMAR, was significantly better in the Phaco group (0.21 ± 0.08) compared to the SICS group (0.32 ± 0.10), with P<0.001. Additionally, a higher proportion of patients achieved UCVA = 6/9 in the Phaco group (85%, 34/40) compared to the SICS group (65%, 26/40); this difference was statistically significant (P=0.04). These findings suggest that phacoemulsification was associated with better early postoperative uncorrected visual outcomes than SICS.

The mean preoperative K1 values were similar between the SICS (43.12 ± 1.20 D) and Phaco (43.28 ± 1.25 D) groups (P=0.56), and there was no significant difference in mean postoperative K1 values at six weeks (43.25 ± 1.18 D vs. 43.33 ± 1.19 D; P=0.71). The mean preoperative K2 values were also comparable (44.23 ± 1.30 D in SICS vs. 44.17 ± 1.22 D in Phaco; P=0.74). However, the mean postoperative K2 was significantly higher in the SICS group (44.93 ± 1.28 D) compared to the Phaco group (44.38 ± 1.20 D), with P=0.02. This suggests a greater steepening of the cornea postoperatively in patients undergoing SICS.

In the present study, the demographic parameters, including mean age and gender distribution, were comparable between the SICS and phacoemulsification groups, consistent with observations by Gogate *et al*.[9] and Rho and Joo[10], who reported no significant demographic differences influencing postoperative
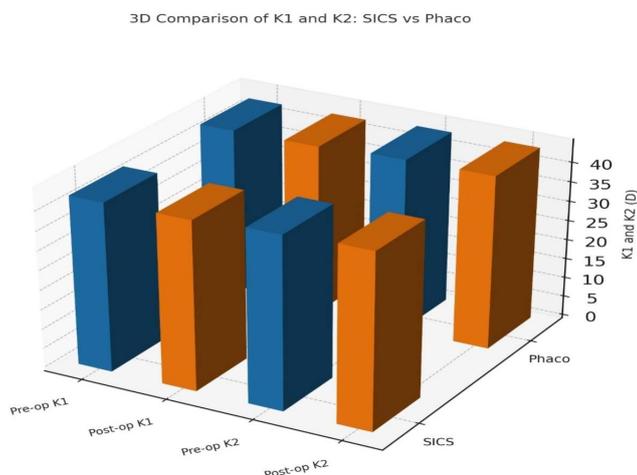
3D Comparison of K1 and K2: SICS vs Phaco

Fig. 1. Changes in keratometric readings (K1 and K2) before and after surgery in SICS and Phaco groups

Table 1: Demographic distribution

Demographic Variable	SICS (n=40)	Phaco (n=40)	P value
Mean age (years)	63.4 ± 6.2	62.7 ± 5.9	0.61
Male: Female	24:16	22:18	0.65
Mean axial length (mm)	23.2 ± 0.8	23.3 ± 0.7	0.58

Table 2: Mean preoperative and postoperative corneal astigmatism

Preoperative and Postoperative Corneal Astigmatism	SICS (n=40)	Phaco (n=40)	P value
Mean pre-op astigmatism (D)	1.11 ± 0.35	1.08 ± 0.32	0.72
Mean post-op astigmatism at 6 weeks (D)	1.68 ± 0.42	0.88 ± 0.29	<0.001

Table 3: Surgically induced astigmatism (SIA)

SIA	SICS (n=40)	Phaco (n=40)	P value
Mean SIA (D)	0.61 ± 0.25	0.21 ± 0.18	<0.001

Table 4: Uncorrected visual acuity (UCVA) at 6 weeks

UCVA (logMAR)	SICS (n=40)	Phaco (n=40)	P value
Mean UCVA	0.32 ± 0.10	0.21 ± 0.08	<0.001
% patients with UCVA = 6/9	65% (26/40)	85% (34/40)	0.04

Table 5: Change in keratometric readings (K1 and K2)

K1 and K2	SICS (n=40)	Phaco (n=40)	P value
Mean pre-op K1 (D)	43.12 ± 1.20	43.28 ± 1.25	0.56
Mean post-op K1	43.25 ± 1.18	43.33 ± 1.19	0.71
Mean pre-op K2 (D)	44.23 ± 1.30	44.17 ± 1.22	0.74
Mean post-op K2	44.93 ± 1.28	44.38 ± 1.20	0.02

refractive outcomes. The mean axial length and preoperative corneal astigmatism were also similar between groups, echoing findings by Shimizu *et al.*[11], who highlighted that baseline ocular biometry typically does not differ significantly among patients undergoing either technique.

However, at six weeks postoperatively, our study observed a significantly higher mean postoperative corneal astigmatism in the SICS group (1.68 ± 0.42 D) compared to the Phaco group (0.88 ± 0.29 D; P<0.001). This finding aligns closely with results reported by Gogate *et al.*[9] and Rho and Joo[10], who demonstrated that SICS tends to induce greater astigmatic change, primarily due to larger scleral tunnel incisions. Similarly, the mean surgically induced astigmatism (SIA) in our series was significantly higher in SICS (0.61 ± 0.25 D) than in Phaco (0.21 ± 0.18 D), which corroborates with the work of Malik *et al.*[12] and Basti *et al.*[13], both of whom reported higher SIA with SICS attributed to the longer and more superiorly placed incision.

The mean uncorrected visual acuity (UCVA) at six weeks, measured in logMAR, was better in the Phaco group (0.21 ± 0.08) than the SICS group (0.32 ± 0.10; P<0.001). This is in agreement with findings by Gogate *et al.*[9] and Joo and Kim[14], who noted superior early postoperative UCVA with Phaco due to minimal disruption of corneal curvature and reduced astigmatism. Furthermore, a significantly higher proportion of patients achieved UCVA = 6/9 in the Phaco group (85%) compared to the SICS group (65%; P=0.04), similar to trends described by Rho and Joo[10] and Zhang *et al.*[15], who highlighted faster and better unaided visual recovery with Phaco.

Regarding keratometric changes, the preoperative K1 and K2 values were statistically comparable, which

is consistent with the observations by Kimura *et al*.[16]. However, the mean postoperative K2 was significantly higher in the SICS group (44.93 ± 1.28 D) compared to the Phaco group (44.38 ± 1.20 D; P=0.02). This greater postoperative steepening in SICS patients mirrors the findings of Malik *et al*.[12] and Narendran *et al*.[17], who noted that larger superior incisions result in corneal flattening along the incision meridian and compensatory steepening of the vertical meridian, thereby increasing K2 values.

In contrast, Phaco, with its smaller and more temporally placed incision, leads to minimal alteration in corneal curvature, as supported by studies from Vajpayee *et al*.[18] and Rajappa *et al*.[19]. Additionally, Gokhale *et al*.[20] reported that temporal Phaco incision placement reduces surgically induced astigmatism and contributes to better visual outcomes, which may partly explain the better postoperative UCVA in our Phaco cohort.

CONCLUSION

In this study comparing small incision cataract surgery (SICS) and phacoemulsification, the baseline demographic and ocular parameters, including age, gender distribution, axial length, and preoperative corneal astigmatism, were comparable between the two groups, indicating an even distribution of patients. Postoperatively, however, distinct differences emerged: SICS was associated with a significant increase in corneal astigmatism and higher surgically induced astigmatism, whereas phacoemulsification resulted in a reduction of astigmatism. Patients undergoing phacoemulsification achieved better early uncorrected visual acuity, with a greater proportion attaining satisfactory functional vision in the early postoperative period. Keratometric analysis further showed that SICS led to a greater steepening of the cornea postoperatively, particularly in the steep meridian, while phacoemulsification preserved the preoperative corneal curvature more effectively. Collectively, these findings highlight that although both techniques are effective for cataract extraction, phacoemulsification offers superior early visual outcomes and induces less corneal astigmatism, underscoring its advantage in terms of faster visual rehabilitation and refractive predictability.

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