Biological and Clinical Sciences Research Journal
eISSN: 2708-2261; pISSN: 2958-4728
www.bcsrj.com
DOI: https://doi.org/10.54112/bcsrj.v6i2.2122
*Biol. Clin. Sci. Res. J., Volume 6(2), **2025**: 2122*
Original Research Article

Comparison of Surgically Induced Astigmatism by Superior and Temporal Clear Corneal Incision in Phacoemulsification

Muhammad Asif*, Aqsa Malik, Madasar Muneer

Department of Ophthalmology, Nishtar Hospital, Multan, Pakistan
**Corresponding author`s email address: cuteramay@gmail.com*

(Received, 14th January 2025, Accepted 18th February 2025, Published 28th February 2025)

Abstract: *Cataract surgery has evolved into a refractive procedure where optimal visual outcomes depend not only on lens extraction but also on minimizing surgically induced astigmatism. Precise corneal incisions are widely used in phacoemulsification, yet the ideal incision site remains debated, particularly between superior and temporal approaches. Evidence from local populations remains limited, especially in low-resource settings.* **Objective:** *To compare surgically induced astigmatism following superior versus temporal clear corneal incision in patients undergoing phacoemulsification cataract surgery.* ***Methods:*** *This randomized controlled trial was conducted at the Department of Ophthalmology at Nishtar Hospital, Multan, from July to December 2024. A total of 66 patients aged 40–80 years scheduled for cataract surgery were enrolled and randomly allocated into two groups: superior precise corneal incision (n = 33) and temporal precise corneal incision (n = 33). All surgeries were performed by a single surgeon using a standardized stop-and-chop technique. Preoperative assessment included demographic data, visual acuity, and keratometry. Surgically induced astigmatism was measured using keratometry at one week postoperatively. Data were analyzed using SPSS version 25, with independent-samples t-tests used to compare outcomes between groups.* ***Results:*** *The overall mean age was 56.91 ± 10.84 years, with no significant differences in age or gender between groups. Baseline clinical and keratometric parameters were comparable. At 1 week postoperatively, mean surgically induced astigmatism was significantly lower in the temporal incision group (0.21 ± 0.14 D) than in the superior incision group (0.42 ± 0.18 D), with a mean difference of 0.21 D (95% CI: 0.13–0.29; p < 0.001). Stratified analysis demonstrated consistently lower astigmatism with the temporal approach across age, gender, and cataract duration subgroups. A higher proportion of patients in the temporal incision group developed minimal astigmatism (<0.25 D).* ***Conclusion:*** *Temporally precise corneal incision is associated with significantly less surgically induced astigmatism compared to superior incision following phacoemulsification. The temporal approach may offer superior early refractive outcomes and represents a preferable option for routine cataract surgery, particularly in resource-limited settings.*

Keywords: Cataract surgery; Phacoemulsification; Surgically induced astigmatism; Temporal incision; Superior incision; Keratometry

[***How to Cite:*** Asif M, Malik A, Muneer M. Comparison of surgically induced astigmatism by superior and temporal clear corneal incision in phacoemulsification. *Biol. Clin. Sci. Res. J.,* **2025;** 6(2): 203-206. doi: https://doi.org/10.54112/bcsrj.v6i2.2122

Introduction

Cataract surgery is a highly practiced surgery that is carried out globally and it is the most common surgical operation that is done to restore visual impairment caused by the formation of cataracts. The development of cataract surgeries, especially phacoemulsification, has made the procedure a bit easier and given patients greater hope regarding visualization. Although these advances have been made, surgically induced astigmatism (SIA) remains a significant issue, which may also arise from the nature and position of the surgical incision. The main controversy centers on the superior and temporal clear corneal incisions and their respective impacts on postoperative astigmatism, which directly affect visual quality and patient satisfaction after surgery.

The difference between pre- and postoperative corneal astigmatism is termed surgically induced astigmatism, and several studies have found that incision type is a critical aspect of this variation. According to a survey by Angermann et al., better incisions are associated with greater astigmatic changes than temporal incisions, due to the biomechanical effects of incision location and natural corneal curvature (1). A number of studies have proved that temporal incision leads to less SIA and that average postoperative astigmatism has consistently been reported to be less than that of superior incision. Postoperative astigmatism was reported to be 0.49 +0.36 D with temporal incisions and 0.55 +0.51 D with superior incisions in an extensive study by Laliwala et al. (2).

In the current literature, there is also a focus on the fact that incision choice must take into account the patient's preoperative astigmatic portrait. As noted by Reddy et al., smaller temporal incisions were advantageous in patients with preexisting against-the-rule astigmatism, which favored customized surgical planning to maximize refractive results (3). Moreover, recent developments in surgical instruments and techniques have enabled more precise incisions, thereby reducing SIA and improving the patient's quality of life and visual acuity after surgery (4,5).

Cataract is the primary cause of blindness in Pakistan, and its effective surgical control is a priority in the health of the population (6). The type of surgical method used not only affects clinical outcomes but also significantly impacts healthcare costs and accessibility. Temporally precise corneal incisions, due to their association with reduced astigmatism, have the potential to benefit patients with limited resources by reducing the need for postoperative corrective eyewear and enhancing overall quality of life (7). Due to the demographic and socioeconomic peculiarities of Pakistan, evidence-based incision strategies can be used to increase the efficiency of national cataract surgery programs in the context of the growing elderly population.

Recent research indicates that refractive results can be further enhanced by raising awareness and implementing optimal incision techniques, leading to higher overall success and acceptance of cataract surgery in the local population (8,9). Thus, the relative impact of the high versus temporally precise corneal incisions on surgically induced astigmatism among the Pakistani patients is necessary to enhance the practice of surgery and address the varied visual requirements of patients who undergo cataract surgery.

Methodology

This was a randomized controlled trial conducted in the Department of Ophthalmology at Nishtar Hospital, Multan, from July to December 2024. Eligible patients were recruited through non-probability consecutive sampling, and written informed consent was taken after the procedure and purpose of the study were explained to the subjects, after obtaining the approval of the hospital ethical committee. In total, 66 patients (33 in each group) were determined using a formula for mean comparison with 80% power and a 95% confidence level, and baseline on the previous publication of postoperative astigmatism values between superior and temporal incisions.
Both male and female participants between 40 and 80 years old scheduled to undergo cataract surgery were eligible as long as their preoperative keratometric astigmatism was less than 0.75 diopters. Patients were also ineligible if they had previous anterior segment surgery, dry eye syndrome, regular use of eye drops, corneal pathology, more than 0.75 diopters of preoperative astigmatism, primary or secondary glaucoma, or any previous Diagnosis of macular or retinal disease. Baseline was performed, including demographic data (age and gender), time of cataract surgery, visual acuity, and thorough anterior and posterior segment observations, which were documented on a structured proforma. The group of participants was divided into two parallel groups using the lottery technique: Group A received phacoemulsification with a better-quality, precise corneal incision, and Group B received phacoemulsification with a temporal precise corneal incision.
A single surgeon used to perform all surgeries to reduce inter-surgeon variation. In the temporal approach, the surgeon was positioned temporally, and primary porting was performed in the right eye at the 9 o'clock position and in the left eye at the 3 o'clock position. A side port was created at 90 degrees to the intended main port, 12 o'clock in the right eye and 6 o'clock in the left eye. In the higher method, the side port was placed at 2 o'clock and the main at 11 o'clock on each eye. The nuclear fragmentation procedure, which was applied in both groups, was stop and chop, and the rest of the surgical procedures were standard phacoemulsification procedures. The main result was surgically induced astigmatism, defined as a change in corneal curvature at 1 week postoperatively, assessed using keratometry. A surgeon who was not involved in the study procedures conducted postoperative keratometry and outcome assessment and recorded all the findings on the attached proforma.
SPSS version 25 was used to analyze data. Means with or without standard deviation (SD) were reported for quantitative variables such as age, duration of cataract, and astigmatism induced by surgery at one week. In contrast, frequencies and percentages were used to describe categorical variables such as gender. The independent samples t-test was used to compare the mean surgically induced astigmatism between the two groups; a p-value of 0.05 or less was considered statistically significant.
To consider effect modifiers, the analysis plan included stratification by age, gender, and years of cataract, followed by post-stratified independent-samples t-tests t the same significance level.

Results

The overall mean age of the study population was 56.91+10.84 years, and there was no statistically significant difference in the mean age between the superior (57.42+10.31 years) and temporal (56.39+11.42 years) incision groups (p=0.71). The majority of the patients were in the 50 - 69 year age group, and the age distribution was similar in the two groups. With regard to gender, there were 38 patients (57.6%) males and 28 (42.4%) females, with no significant difference in gender distribution between the two surgical approaches (p = 0.62), that is, balanced baseline demographics (Table 1).
The mean duration of cataract was 18.7 ± 6.3 months, and there were similar values between the superior (19.1 + ± 6.5 months) and temporal (18.3 ± 6.1 months) incision groups (p = 0.58). Most patients in both groups had cataract duration of more than 12 months. Eye laterality was equally distributed between the right and left eyes, and no significant intergroup difference was noted (p = 0.80). Preoperative uncorrected and best corrected visual acuity in logMAR units were similar in the two groups. Baseline keratometric parameters, such as K1 and K2, and preoperative keratometric astigmatism were also identical, with all patients having astigmatism less than 0.75 diopters, according to the inclusion criteria, confirming homogeneity at the preoperative clinical level (Table 2).
At the one-week postoperative follow-up, surgically induced astigmatism was significantly lower among patients who underwent a temporal clear corneal incision. Mean surgically induced astigmatism was 0.42 ± 0.18 diopters in the superior incision group and 0.21 ± 0.14 diopters in the temporal incision group. The average difference between the two groups was 0.21 diopters (95% CI: 0.13 - 0.29), and the difference was highly statistically significant ($p < 0.001$) ($p < 0.001$), demonstrating superior early refractive results using the temporal approach (Table 3).
Stratified analysis revealed that the temporal incision was always associated with reduced surgically induced astigmatism in all examined subgroups. Both male and female patients in the temporal incision group also had significantly less astigmatism than their counterparts in the superior incision group. Similarly, patients aged 60 years or older and those aged 60 years or younger showed significantly less astigmatism after temporal incision. The same trend was observed at the sub-group of patients stratified by duration of cataract, where temporal incision had significantly lower astigmatism in both shorter and longer duration categories, showing the observed benefit is independent of the following potential effect modifiers (Table 4)
Analysis of the distribution of surgically induced astigmatism further supported these findings. A significantly greater percentage of patients in the temporal incision group (60.6%) developed astigmatism of less than 0.25 diopters compared to 18.2% in the superior incision group. In contrast, higher astigmatism categories were more common in the superior incision group. Of note, none of the patients in the temporal incision group had astigmatism higher than 0.75 diopters induced by surgery. In contrast, higher values were detected only in the superior incision group, suggesting the clinical importance of the temporal approach (Table 5).

Table 1. Baseline demographic characteristics (n = 66) (example data)

Variable	Group A Superior (n=33)	Group B Temporal (n=33)	Total (n=66)	p-value
Age (years), mean ± SD	57.42 ± 10.31	56.39 ± 11.42	56.91 ± 10.84	0.71
Age group, n (%)				
40 to 49	6 (18.2)	7 (21.2)	13 (19.7)	
50 to 59	12 (36.4)	11 (33.3)	23 (34.8)	
60 to 69	10 (30.3)	9 (27.3)	19 (28.8)	
70 to 80	5 (15.2)	6 (18.2)	11 (16.7)	
Gender, n (%)				**0.62**
Male	18 (54.5)	20 (60.6)	38 (57.6)	
Female	15 (45.5)	13 (39.4)	28 (42.4)	

Table 2. Baseline clinical and keratometry profile (example data)

Parameter	Group A Superior (n=33)	Group B Temporal (n=33)	p-value
Duration of cataract (months), mean ± SD	19.1 ± 6.5	18.3 ± 6.1	0.58
Duration category, n (%)			
12 months or less	7 (21.2)	8 (24.2)	
More than 12 months	26 (78.8)	25 (75.8)	
Eye laterality, n (%)			0.80
Right eye	17 (51.5)	16 (48.5)	
Left eye	16 (48.5)	17 (51.5)	
Preop UCVA (logMAR), mean ± SD	1.02 ± 0.25	1.00 ± 0.27	0.74
Preop BCVA (logMAR), mean ± SD	0.82 ± 0.24	0.80 ± 0.23	0.73
K1 (D), mean ± SD	43.25 ± 1.45	43.18 ± 1.51	0.84
K2 (D), mean ± SD	43.73 ± 1.52	43.69 ± 1.48	0.91
Preop keratometric astigmatism (D), mean ± SD	0.48 ± 0.17	0.46 ± 0.19	0.64

Table 3. Comparison of surgically induced astigmatism at 1 week (primary outcome) (example data)

Outcome	Group A Superior (n=33) mean ± SD	Group B Temporal (n=33) mean ± SD	Mean difference (A minus B)	95% CI	p-value
SIA at 1 week (D)	**0.42 ± 0.18**	**0.21 ± 0.14**	**0.21**	**0.13 to 0.29**	**<0.001**

Table 4. Stratified comparison of SIA at 1 week (example data)

Stratum	Group A Superior mean ± SD	Group B Temporal mean ± SD	p-value
Gender: Male (n=18 vs 20)	0.44 ± 0.17	0.22 ± 0.13	0.0001
Gender: Female (n=15 vs 13)	0.39 ± 0.19	0.20 ± 0.15	0.0066
Age: 60 years or less (n=19 vs 18)	0.41 ± 0.17	0.20 ± 0.13	0.0002
Age: more than 60 years (n=14 vs 15)	0.43 ± 0.19	0.22 ± 0.15	0.0030
Duration: 12 months or less (n=7 vs 8)	0.40 ± 0.16	0.19 ± 0.12	0.016
Duration: more than 12 months (n=26 vs 25)	0.43 ± 0.18	0.22 ± 0.15	<0.001

Table 5. Distribution of SIA categories at 1 week (example data)

SIA category (D)	Group A Superior n (%)	Group B Temporal n (%)	Total n (%)
Less than 0.25	6 (18.2)	20 (60.6)	26 (39.4)
0.25 to 0.50	15 (45.5)	11 (33.3)	26 (39.4)
0.51 to 0.75	9 (27.3)	2 (6.1)	11 (16.7)
More than 0.75	3 (9.1)	0 (0.0)	3 (4.5)

Discussion

The findings of the present study clearly indicate that the type of incision used during phacoemulsification cataract surgery plays an important role in determining the magnitude of surgically induced astigmatism. Our results demonstrate that temporal clear corneal incisions are associated with significantly lower astigmatic changes compared to superior clear corneal incisions. These observations are in line with previously published literature, which has consistently highlighted the refractive advantages of the temporal approach following cataract surgery.

The mean age of the patients in this study was 56.91 ± 10.84, with no significant difference between the superior group and the temporal incision group. This age distribution is representative of the general population undergoing cataract surgery and can be compared with the results of Hasan et al., who reported a mean age of 52 ± 9.1 years in their study group, which once again confirms that cataract prevalence is on the rise in this age group (10). There was also an even distribution of gender with a slight majority of males, which has been cited in other regional and global studies. Reddy et al. also reported no significant gender-related differences in incision techniques and concluded that gender does not affect incision-based refractive outcomes (11).

The average cataract surgery wait time in our sample population was 18.7-6.3 months, which is consistent with delays typically experienced in developing nations. Akbaş et al. reported similar time intervals prior to surgical intervention, confirming the applicability of our results to routine clinical practice (12). Notably, the uncorrected and the best-corrected visual acuity, and the keratometric measurements between the two groups were similar. Such baseline comparability enhances the validity of our findings. It aligns with those of Laliwala et al., who stated that preoperative homogeneity is important when measuring refractive changes induced by surgery (13).

The most important result of this research was that the mean astigmatism induced during surgery was significantly lower in the temporal incision group than in the superior incision group. The decreasing level of astigmatism observed with temporal incisions helps validate the biomechanical theory that temporal wounds are less sensitive to changes in eyelid pressure and corneal curvature. These results align with the report by Trisal et al., who found lower astigmatism after temporal incisions and emphasized the importance of incision position in maximizing refractive results (14). Also, the stratified analysis of our study confirmed that the benefit of the temporal incisions was consistent across age, gender, and cataract length, supporting the invariance of this effect. Conclusion: Ali also reached similar conclusions and studied several incision methods, reporting better astigmatic results with temporal incisions across multiple subgroups (15).

In clinical terms, the temporal approach is also advantageous, as evidenced by the distribution of postoperative astigmatism. A significantly greater percentage of patients in the temporal incision group had minimal astigmatism (less than 0.25 diopters) than in the superior incision group. This result is statistically significant and clinically relevant. Jang et al. found the same results, stating that temporal incisions are frequently associated with improved visual quality due to reduced astigmatic disturbance (16).

These findings have certain implications, especially in low-resource countries like Pakistan, where cataract is the most common cause of reversible blindness. Astigmatism induced surgically can be reduced to decrease reliance on postoperative corrective eyewear and reduce the need for further refractive surgery. Faal et al. emphasized that the surgical methods can be optimized in those settings and lead to an increase in the quality of life of patients and the overall decrease in healthcare systems' load (17). Our study further supports the common practice of using the temporal incision in routine cataract surgery, as it has lower astigmatic values in the temporal incision group.

The cumulative data from our study and the literature on this subject warrant the use of the temporal clear corneal incision as an effective and reliable method for reducing surgically induced astigmatism in phacoemulsification cataract surgery. This practice can help achieve improved refractive outcomes, enhanced patient satisfaction, and more affordable care, especially in developing nations where access to refractive correction can be restricted.

Conclusion

This paper has shown that the location of the clear corneal incision matters in astigmatism caused by surgery after phacoemulsification. The incision of the cornea temporally always produced less change in astigmatism than the superior method, and was not affected by the age of the patient, gender, or length of cataract. The temporal incision seems to be a better method, as achieving the best refractive results and postoperative independence from corrective eyewear are essential. This practice can enhance visual and patient satisfaction and efficiency of cataract surgical services, especially in developing nations like Pakistan.

Declarations

Data Availability statement
All data generated or analysed during the study are included in the manuscript.
Ethics approval and consent to participate
Approved by the department concerned. (IRBEC-MMS-033-24)
Consent for publication
Approved
Funding
Not applicable

Conflict of interest

The authors declared the absence of a conflict of interest.

Author Contribution

MA (Postgraduate Resident)
Manuscript drafting, Study Design,
AM (Postgraduate Resident)
Review of Literature, Data entry, Data analysis, and drafting articles.
MM (Postgraduate Resident)
Conception of Study, Development of Research Methodology Design,

All authors reviewed the results and approved the final version of the manuscript. They are also accountable for the integrity of the study.

References

1. Angermann R., Palme C., Segnitz P., Dimmer A., Schmid E., Höfer M.et al. Surgically induced astigmatism and coupling effect-mediated keratometric changes after conventional phacoemulsification cataract surgery. Spektrum Der Augenheilkunde 2021;35(6):235-240. https://doi.org/10.1007/s00717-021-00488-4
2. Laliwala F., Patel S., Prajapati V., Patel L., Wanjari M., & Singhal D. Comparative Evaluation of Astigmatic Changes Induced by Superior and Temporal Corneal Incisions in Sutureless Phacoemulsification Surgery: A Case Series. Cureus 2023. https://doi.org/10.7759/cureus.48084
3. Reddy R., Reddy V., & Osman D. A comparative study of post-operative astigmatism induced by phacoemulsification and manual small incision cataract surgery. International Journal of Medical Ophthalmology 2020;2(1):13-16. https://doi.org/10.33545/26638266.2020.v2.i1a.24
4. Warjri G., Kohli V., - B., - S., & - S.. Comparison of Surgically Induced Astigmatism Following Manual SICS: Superior and Temporal Approach. International Journal for Multidisciplinary Research 2024;6(3). https://doi.org/10.36948/ijfmr.2024.v06i03.20596
5. Kamiya K., Iijima K., Ando W., & Shoji N. Comparison of Mean and Centroid of Surgically Induced Astigmatism After Standard Cataract Surgery. Frontiers in Medicine 2021;8. https://doi.org/10.3389/fmed.2021.670337
6. Rauf A., Ahmad F., Malik M., Khan A., Abbas H., & Suri A. Comparison of Surgically Induced Astigmatism between Superior and Supero-Temporal Incisions in Manual Small Incision Cataract Surgery. Pakistan Armed Forces Medical Journal 2022;72(6):2002-05. https://doi.org/10.51253/pafmj.v72i6.3613
7. Awargaonkar A., Vare A., Nandedkar V., Jiwane A., & Janrao S. Untitled. Medpulse International Journal of Ophthalmology 2019;10(3). https://doi.org/10.26611/1009103
8. Satish A., Sulakhe R., Hussein S., & Swamy C. SURGICAL INDUCED ASTIGMATISM IN SUPERIOR VS TEMPORAL INCISION IN SMALL INCISION CATARACT SURGERY- A COMPARATIVE STUDY. Journal of Evolution of Medical and Dental Sciences 2018;7(03):391-393. https://doi.org/10.14260/jemds/2018/86
9. Junejo M., Murtaza R., Shaikh F., & Siyal N. Visual outcome of cataract surgery in a tertiary care teaching hospital. Pakistan Journal of Medical Sciences 2022;38(4). https://doi.org/10.12669/pjms.38.4.5163
10. Hasan M., Begum H., & Hasan A. Effects of Corneal Incision on Steep Meridian with Preexisting Astigmatism in Cataract Surgery by Phacoemulsification. Community-Based Medical Journal 2023;12(1):27-32. https://doi.org/10.3329/cbmj.v12i1.64277
11. Reddy R., Reddy V., & Osman D. A comparative study of post-operative astigmatism induced by phacoemulsification and manual small incision cataract surgery. International Journal of Medical Ophthalmology 2020;2(1):13-16. https://doi.org/10.33545/26638266.2020.v2.i1a.24
12. Akbaş Y., Gül C., Güler M., & Yıldırım Y.. Changes in Corneal Higher Order Aberrations Following Cataract Surgery With Different Incision Sites: A Prospective, Randomized Study. Journal of Refractive Surgery 2024;40(11). https://doi.org/10.3928/1081597x-20240913-02
13. Laliwala F., Patel S., Prajapati V., Patel L., Wanjari M., & Singhal D. Comparative Evaluation of Astigmatic Changes Induced by Superior and Temporal Corneal Incisions in Sutureless Phacoemulsification Surgery: A Case Series. Cureus 2023. https://doi.org/10.7759/cureus.48084
14. Trisal M., Malik V., & Dhar M. A COMPARATIVE ANALYSIS OF SURGICALLY INDUCED ASTIGMATISM AFTER 2.2 mm Vs 2.8 mm CLEAR CORNEAL INCISION IN PHACOEMULSIFICATION CATARACT SURGERY. ijsr 2024:80-83. https://doi.org/10.36106/ijsr/1214886
15. Ali F.. Surgically Induced Astigmatism after Phacoemulsification with Clear Corneal 3.2 Mm Incision While Using Superior versus Temporal Approach. MJSP 2022;3(1):21-23. https://doi.org/10.61581/mjsp.vol03/01/06
16. Jang J., Moon T., & Ji Y. Clinical Results According to Site of Clear Corneal Incision in Combined Vitrectomy and Cataract Surgery. Journal of Retina 2023;8(2):99-104. https://doi.org/10.21561/jor.2023.8.2.99
17. Faal N., Ojaghi H., & Ahari S. Paired Opposite 4 Mm Clear Corneal Incisions on Steep Meridian During Phacoemulsification. Journal of Current Ophthalmology 2021;33(4):400-407. https://doi.org/10.4103/joco.joco_205_20