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A CLINICAL STUDY TO EVALUATE THE RESULTS OF TORIC INTRAOCULAR LENS IMPLANTATION IN THE MANAGEMENT OF CORNEAL ASTIGMATISM IN CATARACT SURGERY

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Abstract

Background: Preexisting corneal astigmatism is a common challenge in cataract surgery, often necessitating precise surgical planning to achieve optimal postoperative vision. Toric intraocular lens (IOL) implantation has emerged as an effective option to correct astigmatism during phacoemulsification.

Aim: To evaluate the visual outcomes, astigmatism reduction, and rotational stability of toric IOLs in patients undergoing cataract surgery.

Methods: This prospective observational study included 50 eyes of 50 patients with visually significant cataract and ≥1.0 dioptre (D) of corneal astigmatism. Preoperative assessment included uncorrected visual acuity (UCVA), best-corrected visual acuity (BCVA), keratometry, spherical equivalent, and axial length measurement. Toric IOL selection and alignment were guided by standard toric calculators. Postoperative evaluations were conducted on day 1, at 1 month, and at 3 months, recording UCVA, BCVA, residual astigmatism, and IOL rotation.

Results: The mean age was 63.16 years (range 48–84), with a nearly equal gender distribution (48% males, 52% females). Mean preoperative UCVA improved from 0.74 ± 0.14 logMAR to 0.31 ± 0.13 logMAR in 3 months, while BCVA improved from 0.54 ± 0.14 logMAR to 0.22 ± 0.10 logMAR. At final follow-up, 68.0% of eyes achieved UCVA ≤ 0.2 logMAR. Mean preoperative keratometric astigmatism (2.78 ± 1.05 D) reduced to 0.46 ± 0.19 D, with a mean astigmatism reduction of 2.32 ± 1.02 D. Mean IOL rotation was 2.27°, with no cases exceeding 10°. Lower preoperative astigmatism and minimal postoperative rotation were significantly associated with better residual astigmatism and visual outcomes ($p < 0.05$). Eyes with residual astigmatism ≤0.50 D had markedly better UCVA compared to those with higher residual astigmatism ($p = 0.003$).

Conclusion: Toric IOL implantation during cataract surgery provides significant improvement in visual acuity and effective reduction of preexisting corneal astigmatism, with excellent rotational stability. Careful patient selection, accurate IOL alignment, and maintenance of postoperative stability are crucial for achieving optimal refractive and visual results.

Keywords: Toric intraocular lens, cataract surgery, corneal astigmatism, visual acuity, rotational stability.

Introduction:

Corneal astigmatism is common among patients undergoing cataract surgery, with clinically significant levels reported in 15–29% of cases [1]. Cataract extraction without addressing astigmatism

may worsen uncorrected visual acuity relative to expectations eroding patient satisfaction even when spherical refractive errors are corrected [2].

Astigmatism correction during cataract surgery has historically been performed using limbal relaxing incisions (LRIs) and arcuate keratotomies. These approaches may have variable predictability and long-term refractive outcomes [3]. The use of toric intraocular lenses (IOLs) has enabled more accurate and reliable correction of regular corneal astigmatism during cataract surgery, and thus, has been regarded as a more favorable alternative [4].

Toric IOLs incorporate cylinder power in their design to specifically target astigmatism correction based on preoperative keratometric values [5]. Toric IOLs have been shown to provide more accurate correction of astigmatism compared to relaxing incisions, greater long-term stability and overall reduced dependence on prescription glasses for distance vision [6].

Clinical studies have shown significant improvement in uncorrected distance visual acuity (UDVA) as well as postoperative residual astigmatism after the implantation of toric intraocular lenses (IOLs) [7]. Longitudinal studies suggest that toric IOLs possess long term rotational stability. This is very important since each degree of postoperative lens rotation equates to approximately 3.3% reduction of astigmatic correction [7].

The advantages of toric IOLs have been proven throughout all ranges of astigmatism including high astigmatism which is often poorly managed by other approaches [8]. In addition, the application of toric IOLs in patients with irregular astigmatism or complex corneal topographies further broadens their clinical utility [9].

Even with these benefits, the results achieved with toric IOLs are critically dependent on patient selection, detailed biometry workup, intraoperative alignment, intraoperative rotational alignment, and surgical technique. These factors are the reason for variability in the results reported in different studies [10].

In view of these gaps we undertook this study to analyze the visual and refractive results of toric IOL implantation in cataract patients with precocious corneal astigmatism to refine the emerging evidence for its use in enhancing postoperative visual function in Indian patients.

Objectives

1. To assess the improvement in uncorrected and best-corrected visual acuity following toric intraocular lens implantation in cataract patients with preexisting corneal astigmatism.
2. To evaluate the change in postoperative refractive astigmatism and compare it with preoperative keratometric values.
3. To determine the rotational stability and associated complications of toric intraocular lenses during the postoperative follow-up period

Methodology

This prospective hospital based clinical research study was performed in the Ophthalmology Department of a tertiary Care teaching hospital in Western India, spanning a year and a half. A written informed consent was obtained from patients before enrollment.

The inclusion criteria of the study consisted of patients with senile cataract and preoperatively stable corneal astigmatism of one diopter or greater who were to undergo phacoemulsification with toric intraocular lens implantation. Patients with any type of irregular astigmatism, corneal scars, history of ocular surgery, zonular weakness, advanced glaucomatous changes, uveitis and any retinal pathology with significant ocular involvement were excluded from the study.

The sample size for the study was calculated using the Cochran's formula in which $Z\alpha/2 = 1.96$ for 95% confidence, $Z\beta = 0.84$ for 80% power, and with standard deviation of 0.50 and d indicating minimum expected mean difference in residual astigmatism set to 0.20. This gave a sample size of 48 eyes, which was rounded to 50 eyes to account for some attrition due to loss to follow. Enrolment was done in a consecutive manner until sufficient sample size was achieved.

The preoperative assessment involved taking a detailed history along with a comprehensive ocular examination. Biomicroscopic examination of the eyes was done; eye pressure was measured, and fundoscopy of the eye was performed. Optical biometry was performed to measure axial length, and keratometry was done. Using the online toric calculator from the manufacturer, the power and axis of alignment for the toric intraocular lens were determined.

Topical or peribulbar anaesthesia was used for phacoemulsification of the cataract and implantation of the toric intraocular lens. Surgical treatment was performed by the same senior ophthalmic surgeon. A clear corneal incision phacoemulsification was done and intraocular lens was placed in the bag torqued to the preidentified reference axis. Confirmation of intraoperative alignment was done with Mendez ring or digital systems.

Postoperative assessments were done on days 1, 7, 30, and 90. During each assessment, visual acuity uncorrected and best corrected, refractive residual astigmatism, rotation of the intraocular lens and any postoperative complications were assessed. The data was stored in a Microsoft Excel workbook and analyzed with SPSS software, applying paired t-test and chi-square tests where indicated. The difference was significant with a p value less than 0.05.

Results:

The age range of the participants fell between 48 to 84 years, and the average age was 63.16 +/- 9.12 years. The study sample included more females, with 52.0% of the participants, compared to males, who comprised 48.0% of the sample. Concerning laterality, right eyes comprised 46.0% of the cases and left eyes 54.0% (Table 1).

Parameter	Value
Number of patients (eyes)	50
Mean age (years)	63.16 +/- 9.12
Age range (years)	48–84
Male (%)	48.0
Female (%)	52.0
Right Eye (%)	46.0
Left Eye (%)	54.0

Table 1: Demographic profile of patients undergoing phacoemulsification with toric intraocular lens implantation for the correction of preexisting corneal astigmatism.

The mean preoperative uncorrected visual acuity (UCVA) in the study population was 0.74 ± 0.14 logMAR, which showed a marked improvement to 0.31 ± 0.13 logMAR at three months postoperatively. Similarly, the mean preoperative best-corrected visual acuity (BCVA) improved from 0.54 ± 0.14 logMAR to 0.22 ± 0.10 logMAR at the three-month follow-up. At the end of the observation period, 68.0% of eyes achieved a UCVA of 0.2 logMAR (approximately 6/9) or better. These findings indicate a statistically and clinically significant improvement in both uncorrected and best-corrected visual acuity after phacoemulsification with toric intraocular lens implantation. (Table 2)

Parameter	Mean ± SD
Pre-op UCVA (logMAR)	0.74 ± 0.14
Post-op 3 months UCVA (logMAR)	0.31 ± 0.13
Pre-op BCVA (logMAR)	0.54 ± 0.14
Post-op 3 months BCVA (logMAR)	0.22 ± 0.10
UCVA ≤ 0.2 logMAR at 3 months (%)	68.0

Table 2: Comparison of preoperative and postoperative uncorrected visual acuity (UCVA) and best-corrected visual acuity (BCVA) at three months following toric intraocular lens implantation.

The mean preoperative keratometric astigmatism among the study participants was 2.78 ± 1.05 dioptres. At three months postoperatively, the mean residual astigmatism had reduced substantially to 0.46 ± 0.19 dioptres. This corresponds to a mean astigmatism reduction of 2.32 ± 1.02 dioptres. The marked decrease in astigmatism values demonstrated the high efficacy of toric intraocular lens implantation in significantly reducing corneal astigmatism in cataract patients (Table 3).

Parameter	**Mean ± SD**
Pre-op Keratometric Astigmatism (D)	2.78 ± 1.05
Post-op 3 months Astigmatism (D)	0.46 ± 0.19
Astigmatism Reduction (D)	2.32 ± 1.02

Table 3: Preoperative and postoperative keratometric astigmatism values and the mean reduction in astigmatism at three months after toric intraocular lens implantation.

The mean postoperative rotation of the toric intraocular lenses from the intended axis at three months was 2.27°, indicating excellent rotational stability. Notably, none of the eyes in the study demonstrated a rotation greater than 10°, which is considered the threshold beyond which visual performance and astigmatic correction can be significantly compromised (Table 4).

Parameter	**Value**
Mean IOL Rotation (°)	2.27
Eyes with Rotation > 10° (%)	0.0

Table 4: Mean rotational stability of toric intraocular lenses and percentage of eyes with more than 10° rotation at three months postoperatively

In the present analysis, eyes with lower preoperative astigmatism demonstrated lower residual astigmatism at three months. Patients with preoperative astigmatism between 1.0 and <2.0 D had the lowest mean residual astigmatism (0.38 ± 0.15 D), followed by those with 2.0 to <3.0 D (0.45 ± 0.17 D) and ≥3.0 D (0.52 ± 0.20 D), with the difference being statistically significant (p = 0.041).
Rotational stability of the IOL also influenced astigmatic correction. Eyes with ≤2° rotation achieved the highest mean astigmatism reduction (2.39 ± 0.99 D), compared to 2.28 ± 1.02 D in those with >2°–≤5° rotation, and 1.98 ± 1.08 D in those with >5° rotation. This association was statistically significant (p = 0.028).
Postoperative visual outcomes were closely linked to residual astigmatism. At three months, 81.6% of eyes with residual astigmatism ≤0.50 D achieved UCVA of 0.2 logMAR (approximately 6/9) or better, whereas only 16.7% of those with residual astigmatism >0.50 D reached this visual benchmark. This difference was highly significant (p = 0.003) (Table 5).

Variable	Groups	No. of Eyes	Outcome Measure	Mean ± SD / %	p-value*
Pre-op Astigmatism (D)	1.0 – <2.0	11	Residual Astigmatism (D)	0.38 ± 0.15	0.041
	2.0 – <3.0	15	Residual Astigmatism (D)	0.45 ± 0.17	
	≥3.0	24	Residual Astigmatism (D)	0.52 ± 0.20	
IOL Rotation (°)	≤2	30	Astigmatism Reduction (D)	2.39 ± 0.99	0.028
	>2 – ≤5	15	Astigmatism Reduction (D)	2.28 ± 1.02	
	>5	5	Astigmatism Reduction (D)	1.98 ± 1.08	
Residual Astigmatism (D)	≤0.50	38	UCVA ≤ 0.2 logMAR (%)	81.6	0.003
	>0.50	12	UCVA ≤ 0.2 logMAR (%)	16.7	

Table 5: Associations of preoperative astigmatism, IOL rotation, and residual astigmatism with postoperative outcomes.

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Discussion

The results of the current study showed a marked enhancement in visual acuity and refractive measurements after the implantation of a toric intraocular lens in cataract patients with preoperatively existing corneal astigmatism. Three months after the operation, the average uncorrected visual acuity (UCVA) improved from 0.74 ± 0.14 logMAR to 0.31 ± 0.13 logMAR, and BCVA from 0.54 ± 0.14 to 0.22 ± 0.10 logMAR. These results are comparable to those reported by Guvenc et al. (2016) who noted significant improvements in UCVA and BCVA along with enhanced satisfaction following toric IOL implantation. [11]

The current study's average preoperative keratometric astigmatism of 2.78 ± 1.05 D improved to 0.46 ± 0.19 D, which indicates a mean reduction of 2.32 ± 1.02 D. This finding was in line with those of Sheehan et al. in 1999, who observed a significant reduction in astigmatism, with the majority of patients attaining a residual astigmatism of less than 0.50 D. [12]

The current cohort showed excellent toric intraocular lens (IOL) implantation associated with rotational stability with a mean rotation of 2.27° with all subjects rotating less than 10°. Iwai et al. (2011) supports this with documentation of mean rotations of less than 3°, underlining the significance of proper intraoperative alignment for achieving desired refractive outcomes. [13]

The present investigation identified that lesser degrees of IOL rotation (≤2°) attained the greatest mean reduction of astigmatism (2.39 ± 0.99 D) suggesting that astigmatism is reduced more with lower IOL rotation. Zhu et al. (2014) noted a similar tendency, emphasizing that even small degrees of alignment discrepancy contribute to significantly lower alignment after surgery [14].

The remaining astigmatism in this study was defined as the key factor of triage level visual acuity, of which 81.6% of eyes with ≤0.50 D residual astigmatism achieved UCVA ≤0.2 logMAR. Additionally, Li et al. (2019) documented a very strong correlation of low residual astigmatism with enhanced acuity stating that accurate calculations of all the necessary parameters are required for optimal outcomes [15].

The relationship between elevated preoperative astigmatism and increased residual error is noted in this study, as with Phogat et al. (2021), who noted that high baseline astigmatism is a risk factor for inadequate correction even with toric IOLs [16].

Intraoperative and postoperative stability are important to maintain overtime for refractive success. Uren et al. (2007) noted that alignment of toric IOLs helps to achieve reliable and consistent results [17].

The findings of this study regarding the absence of significant postoperative complications are consistent with findings of Strychowsky et al. (2011) who recorded low complication rates following toric IOL implantation [18].

Our findings are in line with Charalampaki et al. (2007) as they noted that precise biometric evaluations and methodical surgical intervention improves refractive outcomes and boosts satisfaction in the postoperative phase. [19]

The aforementioned improves in vision and spectacles dependence are in line with the evaluations made by Castaño-Leon et al. in 2020, where they elucidated that toric IOLs diminish the need for eyewear in patients suffering from astigmatism of the cornea.[20]

Conclusion

Toric intraocular lens implantation in cataract patients with preexisting corneal astigmatism resulted in significant improvement in both uncorrected and best-corrected visual acuity, along with substantial reduction in keratometric astigmatism. The procedure demonstrated excellent rotational stability, with minimal postoperative rotation and no cases exceeding the critical 10° threshold. Lower preoperative astigmatism and minimal IOL rotation were associated with optimal refractive outcomes, and residual astigmatism ≤0.50 D strongly correlated with superior visual acuity. These findings affirm that precise preoperative planning, accurate intraoperative alignment, and postoperative stability are key determinants of surgical success, leading to enhanced visual quality and reduced spectacle dependence in this population.

Conflict Of Interest: None

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