Original Article

Visual outcome and refractive status with monofocal toric intraocular lens implantation to correct astigmatism during cataract surgery

Mayuri Sh. Patil, Archana S Nikose, Shadwala Bharti

Purpose: Measurement, calculations, visual assessment, and refractive status after monofocal toric intraocular lens (IOL) implantation were the purpose of this study. **Methods:** This was a hospital-based interventional prospective study, where 40 eyes were included with astigmatism of more than 2D. They underwent biometric assessment using Lenstar. Toric IOL power calculation was done based on Barrett's Toric calculation method. Preoperative axis marking was done using both bubble marker and direct slit beam to avoid cyclotorsion in sleeping position. On table, axis marking was reassessed. Post phacoemulsification, monofocal Supra Phob Toric IOL was rotated till its marking matches corneal axis marking. Postoperative best-corrected visual acuity was measured at 1 and 3 months. **Results:** Mean of refractive astigmatism reduced from 3.55 ± 0.97 preoperatively to 0.81 ± 0.28 at 1 month and 0.79 ± 0.27 at 3 months postoperatively. In total, 92.5% had residual astigmatism less than 1D at 3 months postoperatively, while 7.5% eyes had residual astigmatism more than 1D. In total, 72.5% patients had IOL rotation of less than or equal to 5°, 20% patients had it between 6° and 10° and 7.5% eyes had more than 10° at day 7 postoperatively, which required IOL repositioning. **Conclusion:** Accurate measurement of parameters and proper calculation reduce the postoperative residual astigmatism after toric IOL.

Access this article online

Website: www.ijo.in

DOI: 10.4103/ijo.IJO_1272_20

Quick Response Code:

Key words: Astigmatism, Barrett calculator, IOL rotation, phacoemulsification, toric intraocular lens

Cataract is the leading cause of blindness which is responsible for 51% of world blindness.[1] Around, 15–29% cataract patients have pre-existing astigmatism more than 1.50D, while 3–15% of eyes with cataract have greater than 2D.[2] Reducing astigmatism may improve visual outcome after cataract surgery.

Patients with cataract and corneal astigmatism who receive traditional intraocular lens may require additional refractive procedures like limbal relaxing incisions, corneal incisions in steep meridian, and femtosecond laser-associated astigmatic keratotomy.[3] These procedures are associated with some complications, such as lack of precision, delayed wound healing, and corneal epithelial defects.

Astigmatism correction can also be done using toric intraocular lens (IOL) implantation without additional refractive procedures. It is more predictable and precise than corneal or limbal relaxing incisions.[4] The success of toric IOLs is determined by accurate and proper preoperative biometric calculation using lenstar or IOL Master. It also depends on the rotational stability in the capsular bag for longer period.

Toric IOL is made of hydrophobic acrylic material, with stable force haptic design for rotational stability. It has been estimated that 1° of off-axis rotation results in a loss of cylindrical power up to 3.3%.[5] Rotational stability is a crucial factor in the efficacy of toric IOLs.

Major drawback of toric IOL after an uneventful cataract surgery is IOL rotation. It is caused by incomplete viscoelastic clearance,[6] capsulorrhexis size, early postoperative intraocular pressure fluctuations,[7] IOL material and design.[8] The majority of capsular bag fibrosis occurs in the first 3 months of implantation, which also leads to IOL rotation.[9]

Surgeon's accurate surgically induced astigmatism (SIA)[10] is needed for the calculation of the required toric IOL and residual astigmatism after cataract surgery. The total corneal astigmatism in with-the-rule and against-the-rule is overestimated and underestimated, respectively, if posterior corneal astigmatism is ignored.[11] Studies suggest that the Barrett Universal II formula is significantly better than the other formulas in the prediction of actual postoperative refraction.[12,13] The toric IOLs provide better visual acuity with spectacle independence and less residual astigmatism as compared with nontoric IOLs combined with relaxing incisions in patients of cataract with corneal astigmatism.[14]

Methods

This was a hospital-based interventional prospective study carried out at tertiary care hospital. Forty eyes having senile cataract with corneal astigmatism more than 2D fulfilling

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Received: 03-May-2020 Revision: 12-Sep-2020
Accepted: 24-Sep-2020 Published: 23-Nov-2020

Cite this article as: Patil MS, Nikose AS, Bharti S. Visual outcome and refractive status with monofocal toric intraocular lens implantation to correct astigmatism during cataract surgery. Indian J Ophthalmol 2020;68:3016-9.

inclusion and exclusion criteria were selected for this study. Astigmatism more than 2D was used because we just started using toric IOL and wanted to appreciate the changes in astigmatism before and after surgery. By keeping power 80% and confidence interval 95%, the sample size of 40 was taken. The study was approved by institutional ethical committee and abided the Declaration of Helsinki. A written informed consent was taken from each patient and following data was collected, i.e., age, gender, address, contact, telephone number. Chief complaints, any previous history of injury, ocular surgeries, and history of systemic diseases were asked.

Inclusion criteria

All patients who understood the study and willing to sign consent form were included in this study. Patients with all types of senile cataract and regular astigmatism more than 2D were selected.

Exclusion criteria

Patients with irregular astigmatism, corneal disease, abnormal iris, pupil abnormalities, known case of glaucoma, any retinal disease or surgery, amblyopia, strabismus, previous ocular trauma, and previous ocular surgery were excluded.

The presenting distant uncorrected visual acuity (UCVA) and best-corrected visual acuity (BCVA) of all patients were measured using Snellen's visual acuity chart (Appasamy Associates, India) or illiterate E chart. External eye examination, pupillary reaction assessment, and anterior segment examination were performed with a slit lamp (Appasamy Associates, India). Cataract was graded by Lens Opacification Classification System (LOCS) lll classification. Nuclear opalescence 2 (NC2), cortical 1 (C1), and posterior subcapsular (P1) were the minimum score of cataract in each category. Optic disc and macula were examined under full mydriasis with 90D (Volk, USA) by slit lamp biomicroscopy, and 20D (Volk, USA) was used for indirect ophthalmoscopy (AAI07, India).

All patients underwent keratometry, axial length, optical anterior chamber depth, lens thickness, corneal diameter, and IOL power using Lenstar Optical Biometer (Haag-Streit, USA). Surgeon's SIA was calculated from the previous cataract surgeries performed by the surgeon and it was 0.50D. An online toric IOL calculator based on Barrett method (Available at: https://www.apacrs.org/) was used to calculate the toric IOL power with its axis and an appropriate IOL model. The preloaded monofocal Supra Phob Toric IOLs (Appasamy Associates, India) with yellow hydrophobic acrylic material and cylinder powers of 1.50D to 6D were used.

All patients underwent systemic investigations such as measurement of blood pressure, urine routine and microscopy, complete haemogram, fasting blood sugar, and postprandial blood sugar and echocardiogram for physical fitness. All patients underwent for routine preoperative preparation after getting fitness in preanesthetic check-up.

Preoperatively, axis was marked on a slit lamp using both bubble marker and direct slit beam with a marker pen to avoid cyclotorsion in sleeping position. Preoperative axis marking was rechecked again to prevent cyclotorsion. The incision location was on the temporal side or as recommended by a toric calculator. On table, axis marking was confirmed using degree marker and bubble marker. After phacoemulsification, monofocal Supra Phob Toric IOL was inserted in bag under viscoelastic substance and rotated till its marking matches corneal axis marking in all cases.

Postoperatively, patients were followed up on day 1, day 7, 1 month, and 3 months. The surgery was done by one surgeon, while both preoperative and postoperative assessment were done by the another person single handedly. An intended axis and present axis were compared by postoperative corneal markings and postoperative photographs taken on all follow-ups to see any IOL rotation. Metal ring marker with axis marking was used postoperatively to check axis. The patients were assessed for UCVA, BCVA, detailed slit lamp examination, autorefractometry, axial length, and keratometry using Lenstar. Residual sphere was 0.25–0.5D, and the main focus of this study was on the residual cylinder; hence, residual sphere was not considered.

Eyes showing IOL rotation upto 10° on follow-up were left as it is, whereas those above 10° needed IOL repositioning. The rotation of IOL was may be due to the material of IOL and presence of viscoelastic after surgery. Berdahl & Hardten Toric IOL calculator was used to determine the axis of IOL repositioning. This calculator required preoperative

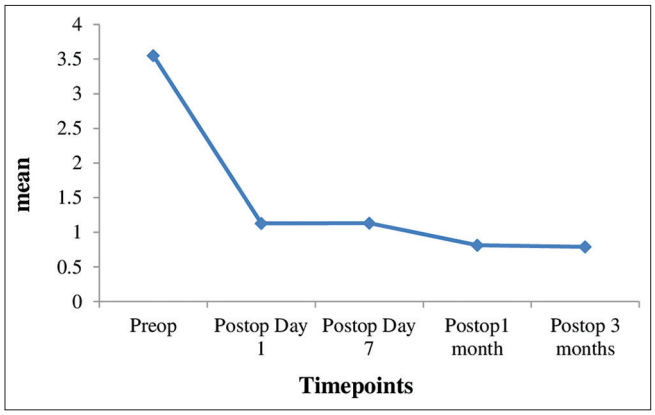

Figure 1: Mean and standard deviation (SD) of refractive astigmatism preoperatively and postoperatively is shown, n = 40. Refractive astigmatism reduced from 3.55 ± 0.97 preoperatively to 0.79 ± 0.27 on 3 months postoperatively

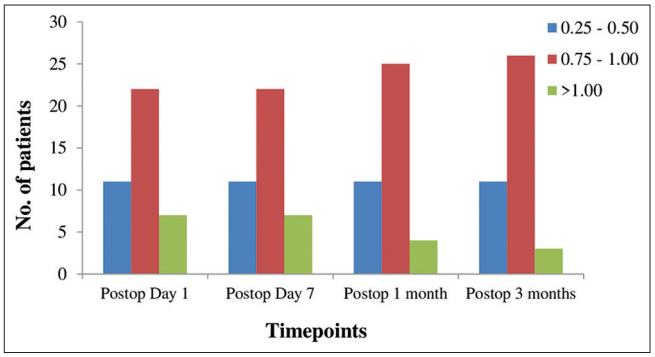

Figure 2: Residual astigmatism on all follow-ups is shown. The residual astigmatism was 0.50D or less in 11 (27.5%) patients on postop day 1 and 7. It reduced further on subsequent follow-ups. Thirty-seven (92.5%) patients had residual astigmatism 1D or less, while three (7.5%) patients had residual astigmatism more than 1D at 3 months

and postoperative keratometry. It also required operative assessment details, postoperative refraction, anterior chamber depth, and axial length. All the above parameters along with axial length were assessed again in the cases where there was rotation. The reassessment of axial length helped us in determining the accurate axis for IOL repositioning.

Results

Fig.1 shows mean and standard deviation (SD) of refractive astigmatism preoperatively and postoperatively. Mean and SD of preoperative refractive astigmatism was 3.55 ± 0.97. It reduced to 1.13 ± 1.20 on day 1 and 7, 0.81 ± 0.28 on 1 month and 0.79 ± 0.27 on 3 months postoperatively.

Fig. 2 shows residual astigmatism on all follow-ups. The residual astigmatism in our study was 0.50D or less in 11 (27.5%) patients on postop day 1 and 7. At 1 month, 25 (62.5%) patients had residual astigmatism of 0.50D or less, 11 (27.5%) patients had residual astigmatism between 0.75 and 1D, while 4 (10%) patients had residual astigmatism more than 1D. At 3 months, 27 (67.5%) patients had residual astigmatism of 0.50D or less, 10 (25%) patients had residual astigmatism between 0.75 and 1D, while 3 (7.5%) patients had residual astigmatism more than 1D.

Table 1 shows toric IOL misalignment after toric IOL implantation. Twenty-nine (72.5%) patients had toric IOL rotation less than or equal to 5° on postop day 1 and day 7, while 32 (80%) had it on postop 1 and 3 months. Eight (20%) patients had toric IOL rotation between 6° and 10° on all follow-ups. Three (7.5%) patients had toric IOL rotation more than 10° on postop day 1 and day 7. Toric IOL repositioning was done in these three cases. None of the patients had toric IOL rotation more than 10° on postop 1 and 3 months.

Table 2 shows the residual cylinder and axis rotation of the three eyes with IOL rotation more than 10°. Toric IOL rotation more than 10° was seen three (7.5%) eyes postoperatively, which required IOL repositioning. In the first case, the toric IOL was found to have rotated by 71° with a residual cylinder of 4.50D. IOL repositioning was performed. In the second case, the toric IOL was found to have rotated by 52° with a residual cylinder of 6D. IOL repositioning was performed after 1 week. In the third case, the toric IOL was found to have rotated by 23° with a residual cylinder of 5D. IOL repositioning was performed.

Table 1: Intraocular lens misalignment after toric IOL implantation

Toric IOL rotation	Number of patients			
	Postop day 1	Postop day 7	Postop 1 month	Postop 3 months
≤5° off axis	29	29	32	32
6-10° off axis	8	8	8	8
>10° off axis	3	3	0	0

Table 2: Residual cylinder of three cases with IOL rotation more than 10°

Number of eyes	Residual cylinder (D)	Axis rotation (degrees)
1	4.50	71
1	6.00	52
1	5.00	23

Discussion

Preexisting corneal astigmatism has a significant impact on the refractive outcome of cataract surgery. One of the several surgical options to correct corneal astigmatism during cataract surgery is the use of toric IOLs. An important advancement in modern cataract surgery is stable and effective toric IOL implantation in the capsular bag during routine phacoemulsification cataract surgery without any corneal procedures.

In our study, mean and SD of preoperative refractive astigmatism was 3.55 ± 0.97. Mean and SD of refractive astigmatism on postoperative day 1 and 7 was 1.13 ± 1.20. Mean and SD of postoperative refractive astigmatism was 0.81 ± 0.28 on 1 month, while it was 0.79 ± 0.27 at 3 months.

Similarly, Khan M *et al*.[15] (2015) evaluated that the mean preoperative keratometric cylinder was 3.78 ± 1.0D in group 1and postoperative refractive value was 1.2 ± 0.68D on day 7. The study included three groups out of which group 1 matched our study and was taken for comparison. Group 1 included 25 eyes with corneal astigmatism more than 2.50D and cataract receiving a toric monofocal IOL. They stated that the preoperative refractive cylinder and keratometric cylinder values can be used interchangeably.

In our study, 36 (90%) patients had residual astigmatism less than 1D at 1 month, while 37 (92.5%) patients had residual astigmatism less than 1D at 3 months. Thirty-six (90%) had residual astigmatism between 0.50 and 3D. Three (7.5%) patients had residual astigmatism more than 3D.

Similarly, Kramer B *et al*.[16] (2016) evaluated the causes for residual astigmatism after toric IOL implantation. They found that 70% of all cases had residual astigmatism between 0.50 and 2D; 90% cases were between 0.50 and 3D.

Hirnschall N *et al*.[17] (2014) compared the astigmatism reducing effect of a toric IOL and peripheral corneal relaxing incisions. We compared our observations with the toric IOL implanted eyes. In total, 96% eyes had residual astigmatism less or equal to 1D in toric IOL group, and 4% eyes had residual astigmatism more than 1D. It was comparable to our study.

In our study, 29 (72.5%) patients had toric IOL rotation less than or equal to 5° on postop day 1 and day 7. Thirty-two (80%) had it on postop 1 and 3 months. IOL rotation of 10° or less was seen in 37 (92.5%) patients on postop day 1 and day 7.

Similarly, Miyake T *et al*.[18] (2014) studied the clinical outcomes and rotational stability of toric IOL to correct preexisting corneal astigmatism in cataract patients. In total, 75.4% patients had toric IOL rotation within ± 5° off axis on postop day 1 and 73.8% had it at 1 week.

Farooqui JH *et al*.[19] (2015) found that IOL misalignment of less than or equal to 5° was present in 46 (71.9%) eyes, while 60 (93.8%) showed IOL misalignment of 10° or less which was comparable to our study.

Conclusion

There are various modalities to correct preexisting corneal astigmatism with cataract surgery. Phacoemusification with toric IOL implantation is one of the most convenient method to correct preexisting corneal astigmatism with cataract surgery in a single procedure. Refractive astigmatism reduced significantly after toric IOL implantation. Visual performance was almost similar to the compared studies. In total, 92.5% patients had residual astigmatism less than or equal to 1.00 D at 3 month postoperative. Patients tolerated slight residual refractive error very well.

Accurate measurement of parameters and the proper method of calculation reduce the postoperative residual astigmatism after toric IOL implantation. Toric IOL implantation is safe, effective, predictable, and precise method to correct pre-existing corneal astigmatism and cataract. It had good rotational stability. It improves postoperative BCVA to 6/6 without glasses, providing high levels of patient's satisfaction.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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