Original Article

Visual outcome and rotational stability of open loop toric intraocular lens implantation in Indian eyes

Arvind Venkataraman[1,2], Kalpana[2]

Purpose: To assess the visual outcome and rotational stability of single-piece open loop toric Intra Ocular Lens (IOL) in a clinical setting. **Materials and Methods:** In a prospective study, 122 eyes of 77 patients were followed up for a period of 12 months after cataract surgery with toric open loop IOL implantation. The pre-operative markings for the position of incision and IOL placement were done under slit lamp by anterior stromal puncture. The visual acuity, refraction, and IOL position were assessed at day 1, 1 week, 1 month, 3 months, 6 months, and 12 months after surgery. **Results:** The mean age of the cohort was 56 yrs (S.D. 13.88; range 16 to 87 years). The mean pre-operative cylinder of corneal astigmatism was 1.37 D. (SD 0.79, range 1.0 to 5.87 D). Mean post-operative refractive cylinder was 0.36 D (SD 0.57, range 0 to 1.50 D) at 12 months. Ninety-seven percent of the eyes were within 1 D of residual astigmatism. Ninety-four percent of patients had uncorrected visual acuity of 20/30 or better. Four eyes required IOL repositioning due to rotation. At 12 months, 96.7% of the IOLs were within 10 degrees of the target axis. There was no rotation seen after 6 months. **Conclusion:** Toric IOLs are very effective and consistent in correcting astigmatism during the cataract surgery. IOL rotation happens mostly within a month of surgery, and if significant, requires early repositioning.

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The cataract surgery has evolved from a mere visual rehabilitation to a refractive procedure. Emmetropia is the expectation of both the patients as well as surgeons. This has been possible by better surgical techniques and improvement in IOL power calculations. But, astigmatism has been a hurdle in achieving good refractive results. Astigmatism, a common refractive error found in 15% to 29% of prospective cataract patients, is caused by the corneal shape, crystalline lens shape, or a combination.[1-3] Limbal Relaxing Incisions (LRI), paired clear corneal tunnels, and astigmatic keratotomies were used to correct the pre-existing astigmatism during cataract surgery.[4-8] These procedures are unpredictable, and the effect regresses over a period of time.[6-8] A recent advance in cataract surgery was the introduction of toric intraocular lenses (IOLs) for the correction of astigmatism. Toric intraocular lenses (IOLs) are becoming more commonly available, allowing more predictable, precise, and stable correction of astigmatism than corneal or limbal relaxing incisions.

This study looked at the results of toric IOLs in correcting astigmatism and the stability of correction in a clinical setting in India.

Materials and Methods

One hundred and twenty two eyes of were followed up for 12 months after cataract surgery with toric open loop IOL implantation. The inclusion criteria being corneal astigmatism of 1 D or more, normal cornea without any primary or secondary pathological conditions affecting its structure, visually significant cataract with intact zonules, residing in the locality so that they can attend all follow-ups post operatively. Exclusion criteria were irregular astigmatism (corneal scar, keratoconus, pterygium), previous kerato-refractive surgery, requirement for other ocular surgery at the time of intraocular lens implantation, zonular dehiscence during surgery, and planned monovision. A comprehensive ophthalmic examination was performed before the surgery. This included manifest refraction, keratometry, topography, slit lamp examination, applanation tonometry, and fundus evaluation through dilated pupils. The spherical IOL power was calculated using axial length from applanation ultrasound biometry and keratometry from a manual keratometer. The online Alcon Toric IOL calculator was used to choose the required toric IOL for implantation. The surgically induced astigmatism of the operating surgeon was found to be 0.37 D for temoral limbal and 0.41 D for supero-temporal limbal incision based vector analysis of 50 surgeries done by the surgeon. Hence, we used the surgeon induced astigmatism as 0.4 D for calculation toric IOLs, and the manufacturers' recommendations were adhered to in each case. Phacoemulsification was performed through a 2.8 mm square wound; the limbal incision was performed at the pre-calculated site to obtain the least post-operative residual astigmatism. After phacoemulsification, a hydrophobic acrylic open loop foldable toric IOL (AcrySof, Alcon, Inc.) was inserted in the capsular bag using a Monarch II injector (Alcon, Inc.). The IOL is available in 7 models (SN60T3, SN60T4, SN60T5, SN60T6, SN60T7, SN60T8, SN60T9), each of which treats different amounts of astigmatism. All 7 toric IOL models have reference marks that indicate the axis of the astigmatic correction.

The site of incision was adjusted to obtain the minimum

[1]Anterior Segment and corneal Surgery, Dr. Arvind Vision Care Eye Hospital, 61, Reddypalayam Road, Mogappair West, [2]Vasan Eye Care Hospital, M77 3rd Avenue, Anna Nagar East, Chennai, Tamil Nadu, India

Correspondence to: Dr. Arvind Venkataraman, 61, Reddypalayam Road, Mogappair West, Chennai - 600 037, Tamil Nadu, India. E-mail: chakraraja@gmail.com

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residual astigmatism following the surgery. The patient was seated in the slit lamp. The chin rest is adjusted so that the eye is level with the marking in the side posts. A torch is held 10 feet away at the level of the eyes as a target for fixation. This will avoid torsion problems in near fixation. Then, the slit beam is rotated to the required axis. The axis of incision is marked at the limbus using a 26 G needle by making anterior stromal puncture. The IOL placement was marked in the clear cornea by diagonally opposite anterior stromal puncture to align the markings of the IOL. These punctures can be made more visible by marking it using a sterile ink pen. Once the IOL was placed in the eye, the surgeon rotated the IOL to align with the reference marks on the cornea. Then, patients were examined postoperatively on day 1, day 7, 1 month, 3 months, 6 months, and 12 months. The position of IOL is assessed in the slit lamp by adjusting the slit to the axis of markings on the IOL after dilatation. The error in lens placement was determined on day 1, and rotational stability was assessed in all the follow-up visits.

Results

One hundred and twenty two eyes of 77 patients were implanted with toric IOLs. The mean age of the patients was 56 years (SD 13.88) (range 16 to 87 years). Fifty-nine percent were males, and 41% were females. Thirty-two patients had uniocular implant and 45 patients had binocular toric IOL implant. The mean axial length was 23.42 (Range 18.55 – 26.22 mm). The mean spherical IOL power was 21.18 D (range 7.5 to 29.5 D). The mean pre-operative refractive cylinder was 1.92 D (SD 0.68, range 0.75 to 6 D), and mean pre-operative keratometric cylinder was 1.37 D (SD 0.79, range 1.0 to 5.87 D). There was a follow-up loss of 4% at the end of 12 months [Table 1].

The toric IOLs used were SN60T3 to SN60T9. T3 was the most commonly used toric IOL model. Most of the IOL implanted have a power in the range of 20-25 D. The post-operative residual cylinder at 12 months was 0.36 D (SD 0.57, range 0 to 1.50 D), and 94% of the eyes had less than 1 D of residual astigmatism [Fig. 1]. Fig. 2 summarizes the mean post-operative residual refractive cylinder for the different models. The target post-operative spherical refraction was -0.19 D (SD 0.27), and actual post-operative residual sphere was -0.32 D (SD 0.08, range -1.25 to + 0.75 D), and SRK-T formula was used in 75 patients.

The uncorrected visual acuity of 20/20 or better was achieved in 73.5%, and 92.6% were 20/30 or better at 12 months after surgery [Fig. 3]. Overall, 96% of our patients had 20/40 or better unaided visual acuity. Of the 5 eyes having UCVA worse than 20/40, 2 eyes had residual refraction, which improved with glasses while one eye had amblyopia, one eye had myopic degeneration, and another eye of a patient had dry macular degeneration.

The misalignment greater than 5 degrees was seen in 2 eyes on day 1 and were repositioned on the same day. One eye was repositioned at one week, and one eye had to be repositioned at 1 month [Table 2]. 96.7% of IOLs stayed within 10 degrees

Table 1: Follow-up loss over 12 months

Visit	Number of eyes (patients)	Percentage of eyes
1 month	1 (1)	0.8
6 months	3 (2)	2.5
1 year	5 (4)	4

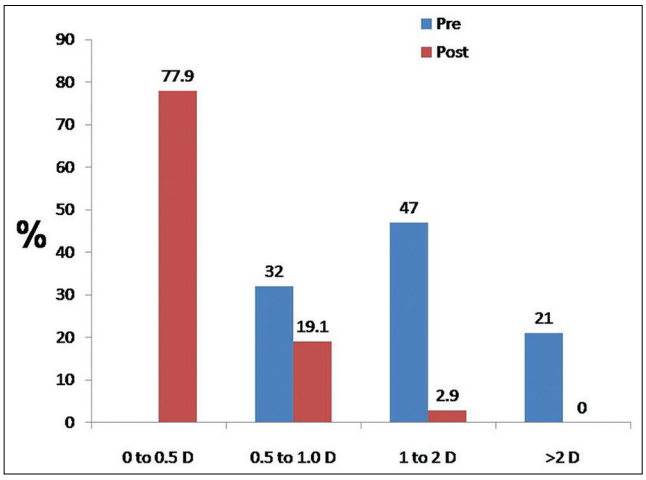

Figure 1: Mean post-operative residual refractive cylinder compared with mean pre-operative refractive cylinder

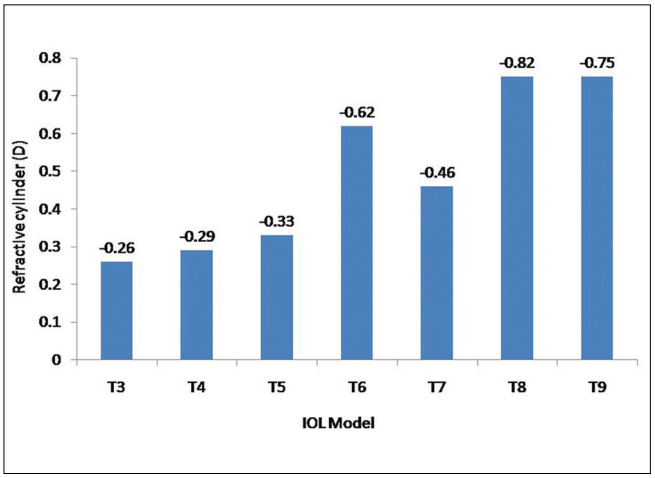

Figure 2: Residual refractive cylinder by model

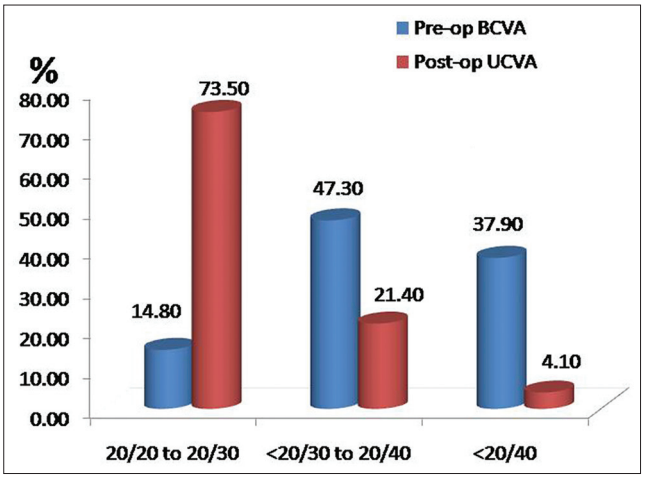

Figure 3: Pre-operative best corrected vision and post-operative uncorrected vision

of placement after the first month [Fig. 4]. In one eye with posterior capsular tear, anterior vitrectomy was done and the toric IOL was placed in the bag, which remained stable at 1 year. One another patient had a small rhexis tear, and IOL was placed into the bag, which was also stable at 1 year.

Discussion

The toric IOL has added another tool to our armamentarium in treating astigmatism during cataract surgery. The toric IOL has been a boon to our practice. There have always been highly demanding patients who were not completely satisfied with the outcome due to the residual astigmatism. Unlike the multifocal implants, we don't restrict our advice of toric lenses in patients with retinal problems or amblyopia. Though toric lens has a high predictability in ensuring accurate astigmatic correction, they are not suitable to correct irregular corneal astigmatism like keratoconus. Conditions that can affect the long term stability of IOL centration like zonular loss or weakness can result in loss of effect due to decentration over a period of time. Hence, we have excluded any case of irregular astigmatism or zonular weakness in our study. Though we have not used paired clear corneal incision or astigmatic keratotomy to reduce corneal astigmatism, it is worth considering these to compliment toric IOL for eyes with astigmatism that can't be corrected by IOL alone.

Good outcomes with toric IOL depend on accurate measurement of keratometry and alignment of IOL marking with estimated steep axis of residual astigmatism. After phacoemulsification, the toric IOL needs to be implanted into the capsular bag. It is essential to remove all the viscoelastices including those behind the IOL. Else, the perfectly positioned lens can rotate in the early post-operative period. We also suggest tapping the optic so that it sticks to the capsule and only gentle hydration of side ports to prevent the fluid from slightly turning the lens. Except for 1 eye, we achieved excellent positioning on post-operative day 1. The positioning of IOL during surgery is not simple in spite of pre-operative marking. The parallax errors can result in misplacement. The error could be in the range of 2-5 degrees depending on the technique and parallax.[9-11] The other factor is the cyclotorsion when the patient lies down for the cataract surgery.[12] In our cohort, we have offset this by marking the patient in the sitting position with the patient seeing straight ahead on a target parallel to the eyes at a distance.

Post operatively measuring the axis of IOL is not fool proof. In a slit lamp examination, it is difficult to measure the precise alignment. The factors that can affect include slight torsion of the eye, convergence, bells phenomenon, and axis marking for the slit is measurable in 5 degree increments. Carey *et al*. had similar findings in their study and found that slit lamp marking and IOL positioning is reliable but not perfect.[13] Hence, we considered < +/- 5 degree as precise positioning. Any misalignment of greater than 5 degrees is considered as a significant rotation in our study.

The rotational stability of toric IOL determines the effectiveness and stability of the outcomes. There is a 3.3% loss of effectiveness for each degree of rotation.[14] If an IOL rotates to 10 degrees, there is a 30% loss in effectiveness of toric IOL. Any rotation beyond 33 degrees will induce more astigmatism. As proven by Patel *et al*., the plate haptic lens tend to rotate more than a loop haptic design in the early post-operative period and loop haptic turn anti-clockwise after 2 weeks.[15] In our study, we found excellent stability of open loop toric IOL in the bag. The most significant variable might have been capsular bag size because early post-operative IOL rotation is more likely to occur in larger diameter bags.[16] Dardzhikova *et al*. also found that the rotation happens in eyes that have larger capsular bags and longer axial lengths.[16] In our cohort, we found that significant rotations happened in eyes with longer axial length. There were 3 patients who had a residual astigmatism of > 1.0 D though the IOL position was matched that planned by the toric calculator. This could not be explained by the change in corneal astigmatism following surgery, and hence, we attribute this due to the internal astigmatism of the eye. Our rotation < 10 degrees is similar to the results of other studies on Alcon Acry Sof Toric IOL.[11,16]

The toric IOL has become an effective tool to give best quality of vision to our patients by almost eliminating pre-operative astigmatism. The results depend on accurate pre-operative assessment of astigmatism, precise marking in the slit lamp,

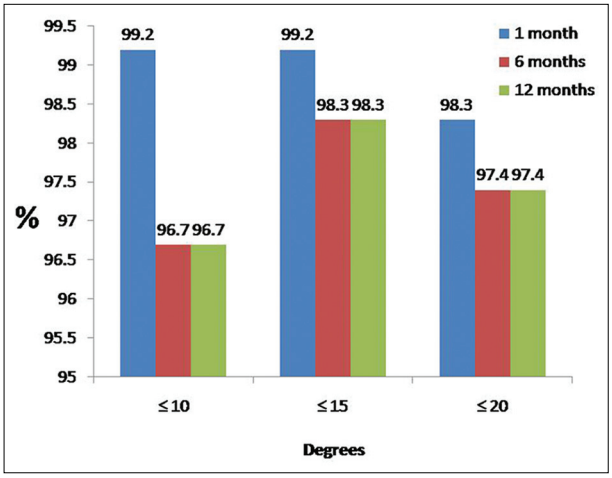

Figure 4: Toric IOL rotation over time

Table 2: Details of eyes were repositioning were performed

IOL (Toric)	Axial lenth	Rotation	Post op visit	UCVA before repositioning	UCVA after repositioning
12.5 D (T9)	26.79 mm	15-20	1 week	20/60	20/25
21 D (T5)	23.52 mm	10	1 day	20/30	20/20
16 D (T3)	25.12 mm	20	1 month	20/30	20/20
23.5D (T3)	23.89 mm	10-15	1 day	20/40	20/20

and perfect placement of IOL during surgery. Our study has shown that open loop toric IOL is successful in correcting astigmatism with excellent rotational stability in the bag.

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