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Original Article

A clinical study to evaluate the results after toric intraocular lens implantation in cases of corneal astigmatism

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ABSTRACT

Background: Modern day cataract surgery aims at a spectacle free vision which becomes difficult in cases with pre-operative astigmatism more than 1.5 D. Implantation of toric intra-ocular lenses (IOL) after phacoemulsification in such eyes is one of the ways to counteract this problem.

Methods: Thirty eyes with pre-operative astigmatism between 1.5 D and 4.5 D were implanted with toric IOLs following uneventful phaco-emulsification. The estimation of the axis of implantation of this toric IOL included calculating the surgically induced astigmatism (SIA) of the surgeon.

Results: Post-operatively, 20 (66.67%) patients had a visual acuity 6/9 or better and 17 (57%) had a visual acuity of 6/6 at 12 weeks. The mean postoperative uncorrected visual acuity (UCVA) was 0.12 ± 0.15 at 12 weeks. The difference between means of preoperative best corrected visual acuity (BCVA) LogMAR and postoperative UCVA at 12 wk LogMAR was found to be statistically significant at $p = 0.001$. Mean (SD) scores of pre-op astigmatism of study group was -2.20 (0.67) and residual astigmatism was -0.32 (0.44).

Conclusions: The difference between means of pre-op astigmatism and residual astigmatism in the study group was significant at $p = 0.001$ with 95% CI -2.22 to -1.50 . This significant difference was because of the toric IOL implantation.

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Introduction

The evolution of cataract surgery from crude methods such as couching and needling to modern day high precision phacoemulsification surgery has been a fascinating journey. The advent of phacoemulsification has transformed the simple surgery of removal of cataractous lens into a refractive surgery by providing the best possible visual recovery to the patient. This has been achieved by a shift to smaller incisions and the management of corneal astigmatism.^{1,2}

The prevalence of astigmatism increases with age and it is estimated that approximately 50% of the population older than 60 years has astigmatism of more than 1.00 Diopter (D).³ Up to 22% of patients undergoing cataract surgery have a preexisting astigmatism exceeding 1.50 D. To optimize visual outcomes and minimize spectacle dependence, this astigmatic component has to be addressed.⁴⁻⁷

The various modalities for correction of astigmatism in patients undergoing cataract surgery include prescription of glasses, contact lenses, corneal relaxing incisions, astigmatic keratotomies, limbal relaxing incisions, excimer laser ablation or toric IOL implantation.⁸ Spectacle use causes meridional magnification and spatial distortion and thus surgical correction of astigmatism is preferred. Correction of astigmatism by surgical techniques on the cornea have several limitations including poor predictability in eyes with higher astigmatism due to variable tissue healing and long term mechanical instability.^{9,10}

Toric intraocular lenses are foldable IOLs that neutralize the preoperative corneal astigmatism by providing a toric refracting surface on the IOL. They represent a stable and predictable method of regular astigmatism correction post phacoemulsification surgery.⁴

With such rapid advances in cataract surgery, it is important to study the final visual recovery following these techniques. A study was therefore conducted at a tertiary care centre to study the results of implantation of toric IOLs in eyes with preoperative corneal astigmatism.

Material and methods

This was an interventional case series where cases of cataract with preexisting corneal astigmatism between 1.5 D and 4.5 D were enrolled in the study. Cases eligible for surgery under local anaesthesia were enrolled in the study. All patients were followed up for a period of 12 weeks (3 months) in the postoperative period.

1. Study protocol:

- a. A detailed history was taken regarding any ocular trauma, previous inflammations or drug intake. History regarding previous use of spectacles was used as an indicator for astigmatic case selection. Patient was also asked about any previous surgeries or any systemic diseases like diabetes mellitus, hypertension, chronic obstructive pulmonary disease and ischaemic heart disease.

2. Examination:

- a. Complete ocular examination was done as follows:

- i. Preoperative uncorrected visual acuity (UCVA) and best corrected visual acuity (BCVA) was recorded on an illuminated Snellen's chart at a distance of 6 m.
- ii. Ocular examination with torchlight including ocular muscle balance was done.
- iii. Detailed examination of each eye under slit lamp for keratic precipitates and lens examination for cataract as per Lens Opacification Classification System III criteria was done.
- iv. Distant direct ophthalmoscopy for evaluation of the density of lenticular opacification.
- v. Detailed fundus examination where possible with direct ophthalmoscopy/slit lamp biomicroscopy with 90 D/indirect ophthalmoscopy.
- vi. Intraocular pressure estimation with applanation tonometer.
- vii. Syringing of the naso-lacrimal duct.
- viii. Systemic investigations as required for cataract surgery were performed. Patients with underlying systemic diseases were evaluated and managed accordingly prior to surgery. Surgery was undertaken only after a pre anaesthetic evaluation.

b. Inclusion criteria

Patients from either sex were included in the study

- i. Patients undergoing phacoemulsification surgery for cataract with preexisting regular corneal astigmatism of equal to or more than 1.50 D and less than 4.50 D were enrolled for the study.
- ii. Cases operated by the same surgeon with the same surgical technique, using the same incision site i.e. 90° were included in the study.

c. Exclusion criteria

- i. Corneal abnormalities.
- ii. Irregular astigmatism.
- iii. Preoperative corneal astigmatism not meeting inclusion criteria.
- iv. Corneal opacities.
- v. Previous corneal/intraocular/refractive surgery.
- vi. Intraoperative cataract surgery complications.
- vii. Iris/pupillary abnormalities.
- viii. Eyes with glaucoma.
- ix. Eyes with amblyopia.
- x. Eyes with any vitreous retinal disorder.

3. Preoperative workup:

The selected patients were subjected to evaluation of the amount and axis of astigmatism with a keratometer. The manual keratometer readings were correlated with auto keratometer readings. IOL power calculation was done using SRK-T formulae with the help of IOL master.

The correct toric intraocular lens model spherical equivalent power was noted after feeding the A-constant of the lens (118.4) into the IOL master. Following this refractive procedure the postoperative spherocylinder was conceived as the sum of the preoperative and the surgically induced spherocylinder. (In other words the surgically induced spherocylinder is the difference between the postoperative and the preoperative spherocylinder).

Optimal axis placement was determined using the online toric IOL calculator after feeding in the keratometry

readings in the steep and flat axis, spherical equivalent power of the toric intraocular lens, site of incision during surgery and the surgically induced astigmatism (SIA). This study used SIA calculator from the website doctor-hill.com to calculate the SIA for the operating surgeon.

4. Preoperative preparation:

Patients were given ciprofloxacin 0.3% eye drops and non steroidal anti inflammatory (NSAID) eye drops and instructed to instill them six hourly on day prior to surgery and once on the morning of the surgery. Pupils were dilated using a combination eye drop containing 0.8% tropicamide and 5% phenylephrine. An intravenous line was secured for emergency purposes. A drop of an NSAID eye drop was instilled to prevent intraoperative miosis and postoperative cystoid macular oedema. The periorbital area along with the lids and the lashes was cleaned with a solution of 5% betadine and a drop of 1% betadine was instilled into the eye. The patient was then taken into the operation theatre.

Once inside the operation theatre, the cornea was marked using a Mendez ring and a Nuijt's toric axis marker to mark the pre calculated actual axis of placement of the toric intraocular lens. The patient was asked to sit upright in primary gaze and the eye was marked with the toric reference corneal marker at the limbus for the 0°, 90° and 180° reference mark. This was done to prevent cyclotorsion that occurs in the supine position, which would give an inaccurate measurement of the angles and ultimately an error in the placement of the intraocular toric lens. The patient was then made to lie down and given anaesthesia.

5. Anaesthesia:

Akinesia and anaesthesia were achieved with a single point inferotemporal quadrant peribulbar injection of 7 ml of a mixture of 2% lignocaine hydrochloride and 0.5% bupivacaine in the proportion of 1:1 with 12.5 U/ml of hyaluronidase given with a sterilized 23 G needle.

6. Surgical procedure:

All the surgeries were carried out through a clear corneal superior incision (90°). After a standard cleaning and draping preparation, a universal wire lid speculum was applied. A 2.8 mm wide self-sealing clear corneal superior incision was then made with a 2.8 mm keratome. Viscoelastic (2% hydroxy propyl methyl cellulose) was injected into the anterior chamber. Using a 26G cystitome needle, a meticulous 5.5 mm continuous curvilinear capsulorhexis was made. Care was taken so that the capsulorhexis was central and did not extend to the periphery.

Two side ports were made and a careful thorough hydrodissection was performed. Fluid was injected right underneath the anterior capsule about 1 mm under the capsulorhexis margin; this separated the entire cataractous lens from the capsular bag and facilitated the rotation of the nucleus. Fluid was then injected into the substance of the lens to demarcate the safe zone for phacoemulsification (hydrodelineation) and to add safety to the posterior capsule. Surgery was carried out with Oertli peristaltic phacoemulsification machine.

After filling the anterior chamber with viscoelastic, the phacoemulsification probe was introduced and the nucleus was removed following trenching method to

divide the nucleus into 4 parts. The left over cortical matter was then removed using bimanual irrigation aspiration. The capsular bag was formed using viscoelastic. The reference marks made preoperatively were used to ascertain the correct horizontal and vertical axis. The foldable IOL was placed in the cartridge coated with viscoelastic and was inserted into an injector. After introducing the injector into the anterior chamber through the 2.8 mm incision, the leading haptic of the folded IOL was inserted into the capsular bag and dialled into position.

The axis of the toric IOL was aligned with the corneal markings using three reference dots present on either side of the toric IOL by dialling the IOL in an clockwise manner. The foldable toric IOL was dialled approximately 15° off axis before the ophthalmic viscosurgical device (OVD) was removed by irrigation and aspiration. After OVD was removed, the IOL was rotated to its final pre decided position by aligning the reference marks on the IOL exactly with the limbal implantation axis marks made during the surgery. Careful alignment and rotational stability in the bag are of prime importance in achieving successful visual outcomes as approximately 3% cylinder power is lost for every 1° of off-axis rotation.

The corneal stroma was hydrated at all the points of entry. Subconjunctival amikacin and dexamethasone were injected in the lower fornix. Eye drop moxifloxacin and eye ointment ciprofloxacin and dexamethasone were put in the eye and pad and bandage was applied.

7. Postoperative management:

All patients were given antibiotic and antiinflammatory tablets twice a day for 5 days. Patients were given tapering doses of eye drop moxifloxacin and dexamethasone starting with 2 hourly for a week and then tapering weekly to stop at 8 weeks post operative. The cases were examined on postoperative days 1, 2, 7, 28, 56 and 84. The following parameters were evaluated:

- Uncorrected distance visual acuity using Snellen's chart.
- Refractive status using a retinoscope.
- Postoperative Keratometry.
- Residual astigmatism.
- Best corrected visual acuity using Snellen's chart.
- Slit lamp biomicroscopy for evaluation of anterior segment and to check the axis of implanted toric IOL.
- Ophthalmoscopy for fundus evaluation.
- Intraocular pressure using a noncontact tonometer.
- Need for distance correction after 12 weeks.

A total of 30 eyes of 30 patients were finally studied. The preoperative and postoperative findings were tabulated, analyzed and subjected to statistical analysis.

Results

1. Age and sex

The study consisted of 30 patients within the age range of 45-85 years with a mean age of 64.47 ± 7.04 years. There were 14 (46.67%) male and 16 (53.33%) female patients. Using chi square test, the difference between gender distribution was not significant ($p = 0.855$).

Table 1a – Descriptive table for BCVA and UCVA at 12 weeks.

	Mean	n	Deviation	Std. error mean
Preoperative BCVA LogMAR	0.69	30	0.36	0.06
Postoperative UCVA at 12 wk LogMAR	0.12	30	0.15	0.02

Table 1b – Difference between mean values of BCVA and UCVA using paired z-test.

	Paired differences					t	df	p-Value
	Mean difference	SD	Std. error mean	95% confidence interval of the difference				
				Lower	Upper			
Preoperative BCVA LogMAR – postoperative UCVA at 12 wk LogMAR	0.56	0.33	0.06	0.44	0.69	9.25	29	0.001

Fig. 1 – Chart comparing pre op astigmatism and post op residual astigmatism at 12 weeks.

2. Visual acuity

The preoperative VA ranged from 6/12 to 1/60 with a mean uncorrected visual acuity (UCVA) on LogMAR being 0.69 ± 0.36 . Postoperatively, 20 (66.67%) patients had a visual acuity 6/9 or better and 17 (57%) had a visual acuity of 6/6 at 12 weeks. The mean postoperative UCVA was 0.12 ± 0.15 at 12 weeks.

The difference between means of preoperative best corrected visual acuity (BCVA) LogMAR and postoperative UCVA at 12 wk LogMAR was found to be statistically significant at $p = 0.001$. This implies that study group showed significant improvement in vision post cataract surgery (Tables 1a and 1b).

3. Residual refractive cylinder:

Fig. 1 compares the preoperative astigmatism with the postoperative astigmatism at 12 weeks. 25 patients (83.33%) had a residual refractive cylinder of 0.75 D or less with 20 patients (66.67%) having a residual cylinder equal to or lesser than 0.50 D. The mean preoperative astigmatism was -2.20 ± 0.68 D whereas the mean post-operative astigmatism was -0.32 ± 0.44 D (Tables 2a and 2b).

Mean (SD) scores of preoperative astigmatism of study group was -2.20 (0.678) and residual astigmatism was -0.32 (0.44). The difference between means of pre-op astigmatism and residual astigmatism in the study group was significant at $p = 0.001$ with 95% CI -2.22 to -1.50 . The difference between preoperative astigmatism and residual astigmatism at 12 wk reflects the amount of astigmatism corrected by the surgery. In the study group this correction of astigmatism can be attributed to the toric IOL.

Table 2a – Comparison of means of pre-op and residual astigmatism.

	Mean	n	Std. deviation	Std. error mean
Preop astigmatism	-2.20	30	0.68	0.12
Residual astigmatism at 12 wk	-0.32	30	0.44	0.08

Table 2b – Comparison of means of pre-op and residual astigmatism.

	Paired differences					t	df	p-Value
	Mean	Std. deviation	Std. error mean	95% confidence interval of the difference				
				Lower	Upper			
Preoperative astigmatism – residual astigmatism at 12 wk	−1.87	0.92	0.16	−2.22	−1.50	−11.07	29	0.001

Spectacle dependence

Of the 30 cataract operated patients with corneal astigmatism, all had a history of spectacle usage preoperatively. 20 (66.67%) patients did not require spectacles post operatively whereas 10 (33.33%) still required to be prescribed glasses post surgery at 12 weeks.

Discussion

This study population with a mean age of 64.47 ± 7.04 years is in consonance with the usual age of cataract surgery and with no gender bias. The mean pre-op BCVA was 6/24 and the mean post op UCVA was better than 6/9. This data suggests a good outcome in eyes with a pre-op astigmatism between 1.5 D and 4.5 D with implantation of a toric IOL following surgery with routine phacoemulsification.

The range of astigmatism for inclusion in this study was between 1.5 D and 4.5 D. Hence the mean preoperative astigmatism of -2.20 ± 0.68 D reflects the general amount of pre-op astigmatism in eye wherein this toric IOL may be required. The mean post-operative astigmatism was -0.32 ± 0.44 D. The difference when compared to the pre-op astigmatism of -2.20 ± 0.68 D is statistically significant ($p < 0.05$). This corroborates that toric IOLs were effective in reducing a pre-op astigmatism of 2.2 D to 0.3 D, which is certainly significant.

Residual astigmatism of 0.50 D or less was seen in 75% of the study population [20/30 (66.67%)]. Since a cylinder of 0.5 D is considered negligible, it implies that 2/3rd of the study population were emmetropic post-operatively which is corroborated with the spectacle dependence post-operatively.

Even in an uneventful cataract surgery, surgically induced astigmatism remains the major hurdle in attaining good unaided visual acuity post surgery. If preexisting corneal astigmatism is not corrected at the time of surgery, it will result in more postoperative astigmatism; therefore, it is important to correct preexisting corneal astigmatism. An important goal of modern cataract and implant surgery is to obtain the most desirable refractive outcome and in doing so, to decrease dependence on spectacle correction.

Total refractive astigmatism represents the sum of corneal and lenticular astigmatism in the preoperative eye. In the postoperative eye, residual astigmatism is generally equal to corneal astigmatism when a spherical IOL is implanted with the removal of crystalline lens, lenticular astigmatism having been eliminated. Correction of astigmatism at the time of cataract surgery can be achieved by many means. Traditionally spherical monofocal intraocular lenses (IOLs) restore best-corrected vision and may lessen the postoperative need for spectacles in patients having less than 1 D of corneal astigmatism. These cases can also be managed by altering the wound of entry. For cases with preoperative astigmatism > 1.5 D and in some patients who receive traditional spherical monofocal IOLs often need spectacles or additional corneal refractive procedures such as limbal relaxing incisions (LRIs), photorefractive keratectomy (PRK), Laser Assisted In Situ Keratomileusis (LASIK) and astigmatic keratotomy. LRIs are also associated with potential disadvan-

tages such as lack of precision, varied healing responses, regression, gaping of wound¹¹ and under correction.¹⁰ Well known potential complications of PRK and LASIK include but are not limited to regression, haze, dry eyes, diffuse lamellar keratitis, undercorrection, and overcorrection.¹² A good alternative in these scenarios is the implantation of toric IOLs.

It is a stable and predictable way of achieving favourable postoperative visual function. Toric IOLs serve the dual purpose of restoring vision deteriorated by cataract along with correcting corneal astigmatism, whereby spectacles are no longer needed. Moreover there is no additional procedure done on the cornea. An IOL is implanted as is the rule in any cataract surgery and in this procedure that simple implantation of a toric IOL has given spectacle free distance vision in 66.67% of the cases. Even in the remaining one third, the maximum residual astigmatism has been only 1 D.

Conclusions

This study shows the value of implanting toric IOL in cases with pre existing corneal astigmatism. The difference between means of preoperative astigmatism and residual astigmatism in the study group was significant at $p = 0.001$ with 95% CI -2.22 to -1.50 . This significant difference was because of the toric IOL implantation in the study group. Most of these patients were spectacle free post surgery. Hence in cases with pre existing corneal astigmatism between 1.5 D and 4.5 D, toric IOL is the best possible intervention and continues to remain the gold standard.

Conflicts of interest

The authors have none to declare.

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