Premium toric IOLs outcomes in visual acuity and rotational stability after implantation in cataract patients

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Objective: To evaluate the visual acuity, refraction and rotational stability after cataract surgery with implantation of toric IOLs.
Design: Retrospective descriptive study
Methods: Patients with corneal astigmatism undergoing cataract surgery with implantation of toric IOLs 677TA were reviewed. The uncorrected visual acuity (UCVA), best corrected visual acuity (BCVA) and residual refraction were evaluated at 1, 3, 6 and 12 months postoperatively. The rotational axis of toric IOLs were assessed at 6 and 12 months postoperatively. These data were analysed for visual outcome and IOLs stability individually.
Results: The mean uncorrected visual acuity decreased from 0.79 logMAR (range 0.18 to 3.00 logMAR, SD = 0.62) to 0.16 logMAR (range 0.00 to 0.54 logMAR, SD = 0.18) in the first month after the surgery. The mean refractive astigmatism decreased from -1.96 (range -3.75 to -0.50 D, SD = 1.09) to -1.22 D (range -3.50 to -0.25 D, SD = 0.83) in the first month. The UCVA, BCVA and refractive astigmatism values were stable during the 1-year follow-up. Intraoperative to 6 months and 1 year postoperative comparison of IOL axis alignment showed a mean of 10.11 degrees (range -17 to +29 degrees, SD = 7.58) and 10.82 degrees (range -22 to 29 degrees, SD = 8.28) respectively.
Conclusion: The toric IOLs 677TA implantation is the good options to correct preexisting astigmatism in cataract surgery. The postoperative refractive astigmatism decreased from the preoperative values and was stable during the 1-year follow-up. Also, the preoperative and postoperative corneal astigmatism were not changed.

Conflicts of interest: Researchers have no financial interest in any products or instruments mentioned in this study.
Keywords: toric intraocular lenses (IOLs), astigmatism, uncorrected visual acuity (UCVA), cyclotorsion

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Introduction

Corneal astigmatism was found in 15-50% of cataract patients. The presence of residual astigmatism refractive error after cataract surgery with intraocular lens implantation can compromise the postoperative level of visual outcome. Corneal astigmatism can be corrected by implanting a toric IOLs, by changing the corneal curvature by excimer laser refractive procedures and by placing relaxing incisions at the steepest meridian to flatten the corneal curvature[1]. The toric IOLs can not only correct the refractive spherical equivalent (SE) but also minimize the residual astigmatism refractive error [1,2,3,4,5,6,7,8]. Superiorly, the toric IOLs can correct up to 8D of astigmatism and have the better visual outcome, whereas relaxing incisions may correct up to 3D of astigmatism[2]. Relaxing incisions may have the risk of infectious keratitis and the refractive results may change over time of the corneal healings.

Toric IOLs can rotate. Small rotations do not affect the astigmatic power, but larger rotations will reduce the power of the IOLs. Within 15 degrees of misalignment, the amount of residual cylinder is approximately 3.3% per degree. A 30 degrees misalignment induced an estimated residual cylinder of 100% of the toric IOL cylinder power[2, 5, 6, 8, 9]. So the success of a toric IOLs is up to its ability to maintain a stable position in the capsular bag. The eye should be marked in an upright position because of the ocular cyclotorsion. The cyclotorsion of approximately 2 to 3 degrees usually occurs, with some patients having up to 14 degrees of cyclotorsion[8]. There are several eye marking techniques for toric IOL alignment. The aim of this study is to evaluate the visual acuity, refraction and rotational stability of the Bi-flex T aspheric toric intraocular lens 677TA after cataract surgery in preexisting corneal astigmatism cases.

Methods

Patients and methods

The 36 eyes of 31 patients were enrolled in this study. All patients underwent the phacoemulsification with toric intraocular lens 677TA implantation. The patients had the following characteristics including having senile cataract that cause the compromised visual acuity, preexisting regular anterior corneal astigmatism. Exclusion criteria were irregular corneal astigmatism, corneal scar, amblyopia, glaucoma, uveitis, diabetic retinopathy, aged-macular degeneration, retinal detachment and other retinal diseases.

After patients were informed about purposes and methods of this study and signed in the consent form, participants who follow inclusion criteria were enrolled in the study. Age, sex, underlying diseases and ocular history were recorded. All patients had a full eye examination with slit-lamp microbioscopy, fundus examination, preoperative distance visual acuity that converting the results into logMAR values, corneal keratometric power, intraocular pressure, corneal topography and IOL calculation by laser interference biometry (IOL master) and immersion technique (A-scan ultrasonography)

The appropriate position of the toric IOLs, including toric IOLs cylinder power and axis placement, was calculated for emmetropia using a program available from the IOL manufacturer.

Intraocular lenses

The toric IOL 677TA was the implanted Bi-Flex T toric IOL, a single-piece aspheric IOL made of hydrophilic acrylic copolymer with intergrated covalently bound benzophenone as an ultraviolet absorbent, having overall diameter of 13.0 mm, double loop haptics, and an optic diameter of 6.0 mm without haptic angulations. The refractive index of the optic material at 23 degree Celsius is 1.46. The IOL is marked with two marks at the edge of the toric IOL optic. The toric IOL is aspheric with neutral asphericity approach with sharp edge following 360 degree to prevent migration of lens epithelial cells and prevent posterior capsular opacification formation. The toric IOL is available in cylinder powers of 1.5 to 9.0 Diopters(D)[1].

Surgical procedure

All surgeries were performed by the same experienced surgeon using a standard technique phacoemulsification with Bi-Flex T toric IOLs implantation between January 2014 and June 2017.

Topical anesthesia and mydriatic eyedrops were instilled in all case prior to the surgical procedure. Preoperatively, the eye was marked at the 3- and 9- o'clock position by the corneal marker. Capsulorhexis size was about 6 mm in diameter. Cataract was removed by phacoemulsification. All toric IOLs were inserted into the capsular bag using a specific injector through the 2.2 mm main incision. After implantation, the toric IOLs was rotated to its final toric IOLs axis referencing by using the Mendez instrument. The ophthalmic viscoelastic device was removed. The sutureless wound closure was performed.

Preoperative and postoperative assessment

Preoperative data included slit-lamp examination, fundus examination, the uncorrected visual acuity (UCVA), the best-corrected visual acuity (BCVA), autorefraction (AR), autokeratometry (AK), IOLs calculation were collected.

Postoperative examinations were performed 1 day, 1 week, and 1, 3, 6, 12 months postoperatively. The research informations included silt-lamp examination, the UCVA, BCVA, AR, AK at 1, 3, 6, 12 months and IOLs axis for evaluating its rotation at 6, 12 months postoperatively. The visual acuity was evaluated by interpreted to logMAR[10] and divided into four groups. Rotational axis of the toric IOL was evaluated by IOL axis measurement after pupil dilatation compared with the axis position at the end of surgery. Clockwise rotation was counted as positive value and counterclockwise rotation as negative value.

If the patient has the postoperative factors that can interfere the visual outcome such as posterior capsular opacity, dry eye or infection, the appropriate treatment had to be done before collecting the research data.

Statistical analysis

Analytic results were calculated from SPSS version 12. The mean values and standard deviations were calculated for every parameters. Normal distribution was checked by using Kolmogorov-Smirnov test. 1-way analysis of variance (ANOVA) was used to analyse the data from preoperative examinations and postoperative examinations and between consecutive postoperative visits individually with a p value less than 0.05 indicating statistic significance.

Ethics

Informed written consent was obtained from all participants. The present study had approved by the Human Research Ethics Committee of Thammasat University (No.1: Faculty of Medicine), Thailand.

Results

The study enrolled a total of 36 eyes from 31 patients (16 males and 15 females) with an age range from 60 to 88 years (mean age 73.29 years). Laterality were 23 right eyes and 13 left eyes. Mean preoperative refractive error were 0.104 D in sphere (SD 3.30, range -5.25 to 6.50 D) and -1.96 D in cylinder (SD 1.09, range -0.50 to -3.75 D). Mean preoperative spherical equivalence were -0.61 (SD 3.33, range -7.125 to 5.125 D). Mean keratometric power in the flattest and steepest meridians of the central cornea were 43.96 (SD 2.08, range 40.00 to 48.25 mm) and 45.65 (SD 2.12, range 41.75 to 50.25), respectively. Mean preoperative uncorrected visual acuity was 0.79 logMAR (SD 0.62, range 0.176 to 3.00). The visual acuity of finger-counting was interpreted to 3.00 logMAR (Table 1).

The means of corneal astigmatism were 1.69, 1.56, 1.50, 1.50, 1.49 D at preoperative and postoperative 1, 3, 6, 12 months respectively. There was no statistically significant difference between the corneal astigmatism preoperatively and postoperatively (*p*=0.10) (Figure 1).

The mean intraocular lens power was 20.04 +/- 2.46 D in sphere (range 14.50 to 24.50) and 2.02 +/- 0.71 D in cylinder (range 1.50 to 3.75).

Table 1: Preoperative Demographic Data (31 Patients, 36 Eyes)

Demographic	Value
Age (Y)	
Mean +/- SD	73.29 +/-7.367
Range	60, 88
Sex (N)	
Male	16
Female	15
Operated eye (N)	
Right	18
Left	8
Both	5
Preoperative refractive astigmatism (D)	
Mean +/- SD	-1.96 +/- 1.09
Range	-0.50, -3.75
Preoperative corneal astigmatism (D)	
Mean +/- SD	1.69 +/- 0.65
Range	0.50, 3.00
Mean refractive spherical equivalent	
Mean +/- SD	-0.61 +/- 3.33
Range	-7.125, 5.125
Preoperative UCVA (logMAR)	
Mean +/- SD	0.79 +/- 0.62
Range	0.176, 3.00

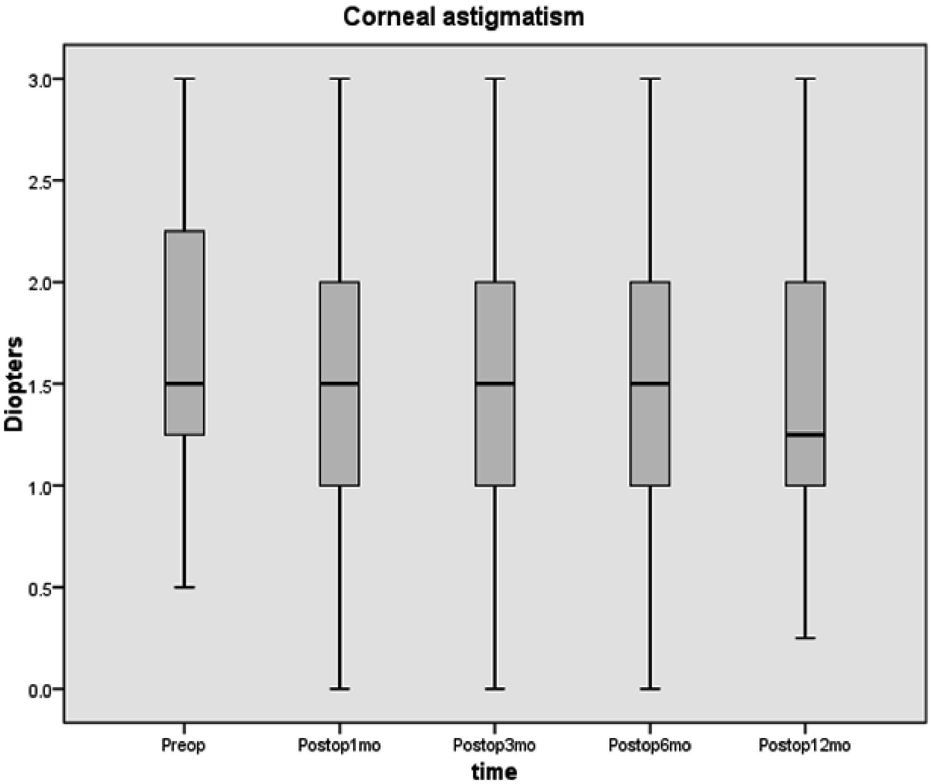

Figure 1: Showed the stable corneal astigmatism over time after phacoemulsification with toric IOL implantations. (n=36, *p*=0.10)

Visual acuity outcomes

Postoperative uncorrected visual acuity (UCVA) and best-corrected visual acuity (BCVA) were evaluated as values in both logMAR and in groups.

The uncorrected visual acuity and best-corrected visual acuity were showed in Figure 2, 3 respectively. Postoperative BCVA was corrected to evaluating the best vision excluding postoperative refractive astigmatism and residual refractive error.

In logMAR, an uncorrected visual improvement from a mean of 0.79 logMAR (range 0.18 to 3.00 logMAR, SD = 0.64) to a mean of 0.14 logMAR (range 0.00 to 0.54 logMAR, SD = 0.17) in the first month, 0.17 logMAR (range 0.00 to 0.54 logMAR, SD = 0.14) in the third month, 0.17 logMAR (range 0.00 to 0.54 logMAR, SD = 0.15) in the sixth month, and 0.17 logMAR (range 0.00 to 0.54 logMAR, SD = 0.15) in one year after the surgery (Figure 2).

The best-corrected visual improvement from a mean of 0.79 logMAR (range 0.18 to 3.00 logMAR, SD = 0.64) to a mean of 0.10 logMAR (range 0.00 to 0.54 logMAR, SD = 0.13) in the first month, 0.09 logMAR (range 0.00 to 0.54 logMAR, SD = 0.13) in the third month, 0.09 logMAR (range 0.00 to 0.40 logMAR, SD = 0.11) in the sixth month, and 0.10 logMAR (range 0.00 to 0.40 logMAR, SD = 0.12) in one year after the surgery (Figure 3).

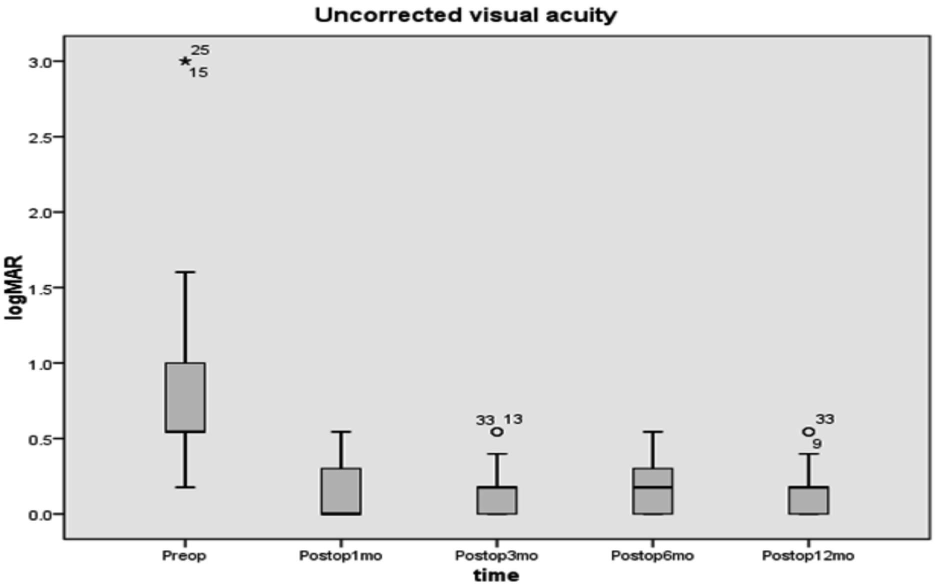

Figure 2: showed distance uncorrected visual acuity (UCVA) over time after phacoemulsification with toric IOL implantations.

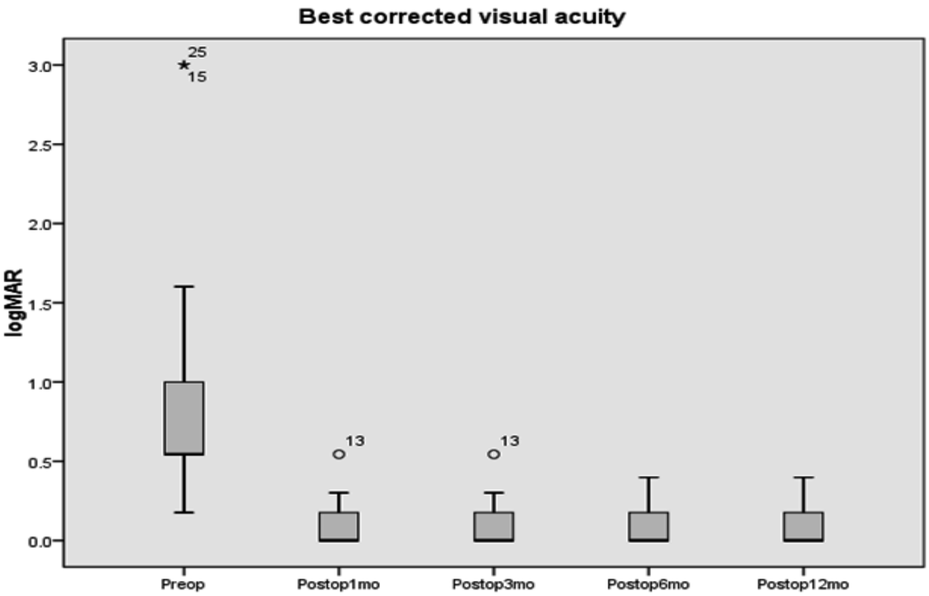

Figure 3: showed distance corrected visual acuity (BCVA) over time after phacoemulsification with toric IOL implantations.

In groups, we divided the visual acuity levels into four groups; group 1 meant 20/20 to better than 20/40, group 2 meant 20/40 to better than 20/70, group 3 meant 20/70 to better than 20/200 and group 4 meant 20/200 and less than 20/200.

Both UCVA and BCVA improved statistically significantly in groups ($p<0.001$). Preoperative patients mainly classified in group 3 (17 eyes, 51.5%) that meant 20/70 to better than 20/200. Postoperatively, the UCVA was mainly group 1 in 26 eyes (78.8%), 28 eyes (84.8%), 27 eyes (81.8%) and 26 eyes (78.8%) at postoperative 1, 3, 6 months and 1 year respectively. The BCVA was mainly group 1 in 30 eyes (90.9%), 32 eyes (97.0%), 31 eyes (93.9%) and 30 eyes (90.9%) at postoperative 1, 3, 6 months and 1 year respectively (Figure 4, 5).

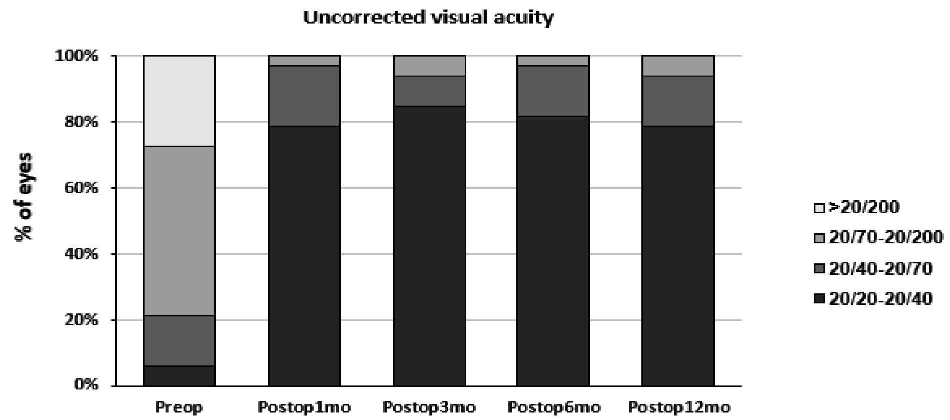

Figure 4: Table grafts showed the percentage of the number of the eyes in ranging groups of distance uncorrected visual acuity over time after phacoemulsification with toric IOL implantations.

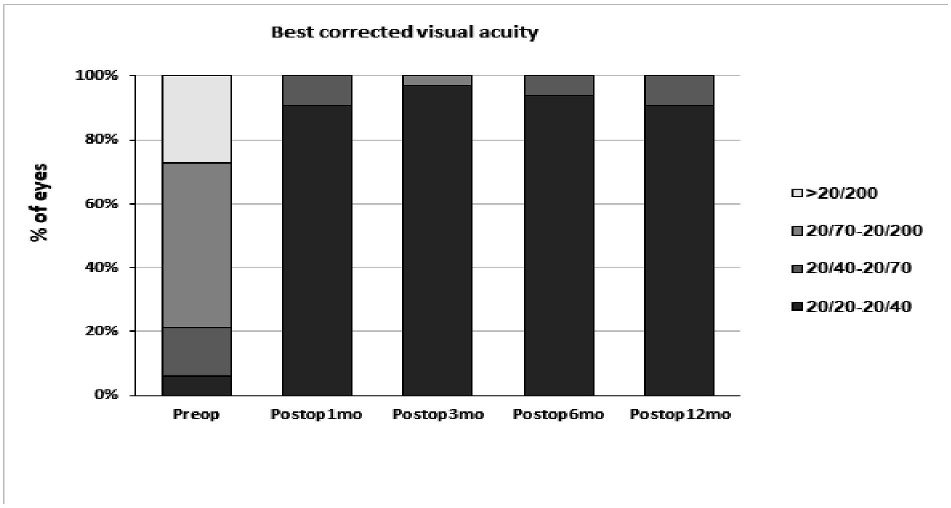

Figure 5 Table grafts showed the percentage of the number of the eyes in ranging groups of the best-corrected visual acuity over time after phacoemulsification with toric IOL implantations.

Refractive outcomes

A spherical equivalent result comparing preoperative and postoperative was present in Figure 6. A reduction of spherical equivalent from a mean of -0.61 (range -7.125 to 5.125 D, SD = 3.33) to -0.32 D (range -1.625 to 1.75 D, SD = 0.67) in the first month, -0.26 (range -1.625 to 1.625 D, SD = 0.71) in the third month, -0.29 (range -1.50 to 1.625 D, SD = 0.71) in the sixth month, and -0.25 (range -1.875 to 1.625 D, SD = 0.77) in one year after the surgery.

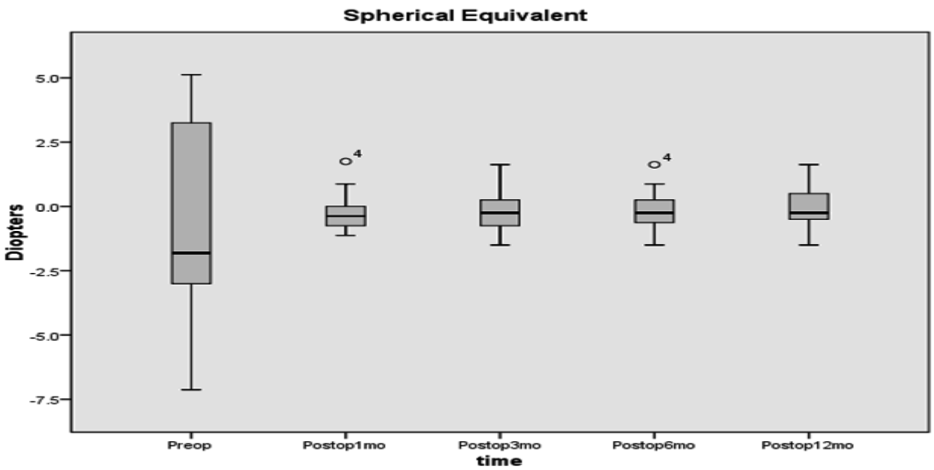

Figure 6: showed Spherical Equivalent (S.E.) over time after phacoemulsification with toric IOL implantations

A reduction in refractive astigmatism was from a mean of -1.96 D (range -0.50 to -3.75 D, SD = 1.09) to -1.22 D (range -0.25 to -3.50 D, SD = 0.83) in the first month,-1.27 D (range -0.25 to -3.25 D, SD = 0.78) in the third month, -1.37 D (range -0.25 to -3.50 D, SD = 0.82) in the sixth month, and -1.46 D (range -0.25 to -3.50 D, SD = 0.81) in one year after the surgery (Figure 7).

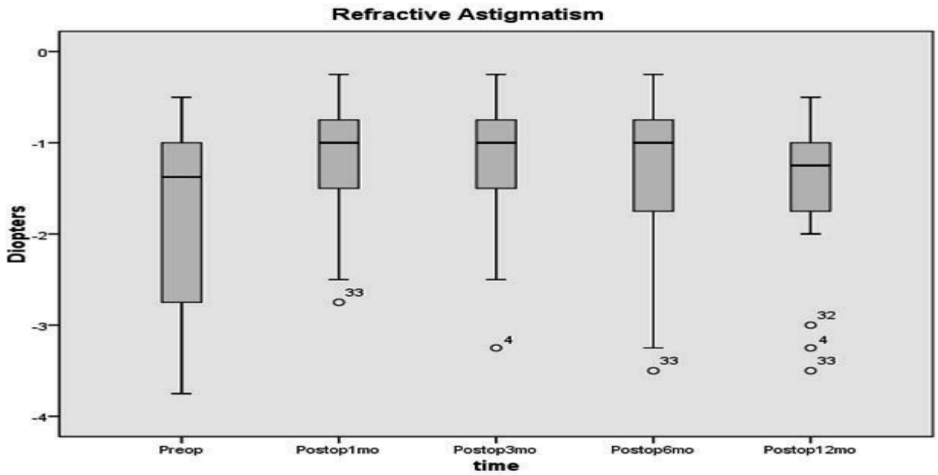

Figure 7: showed Refractive astigmatism over time after phacoemulsification with toric IOL implantation

Misalignment and IOLs rotation outcomes

In the clockwise (plus) rotation group, the mean IOLs rotation was 8.19 +/- 5.68 degrees (range 0 to 17 degrees) and 8.81 +/- 6.61 degrees (range 0 to 22 degrees) in postoperative sixth months and one year respectively. In the counterclockwise (minus) rotation group, mean IOLs rotation was 10.13 +/- 9.69 degrees (range 0 to 29 degrees) and 10.80 +/- 10.30 degrees (range 0 to 29 degrees) in postoperative sixth months and one year respectively. There was no statistically significant difference between counter-clockwise and clockwise IOL rotations (p=0.20) (Figure 8). The mean of all IOLs rotation was 10.11 +/- 7.58 degrees and 10.82 +/- 8.28 degrees in postoperative sixth month and one year respectively (Figure 9).

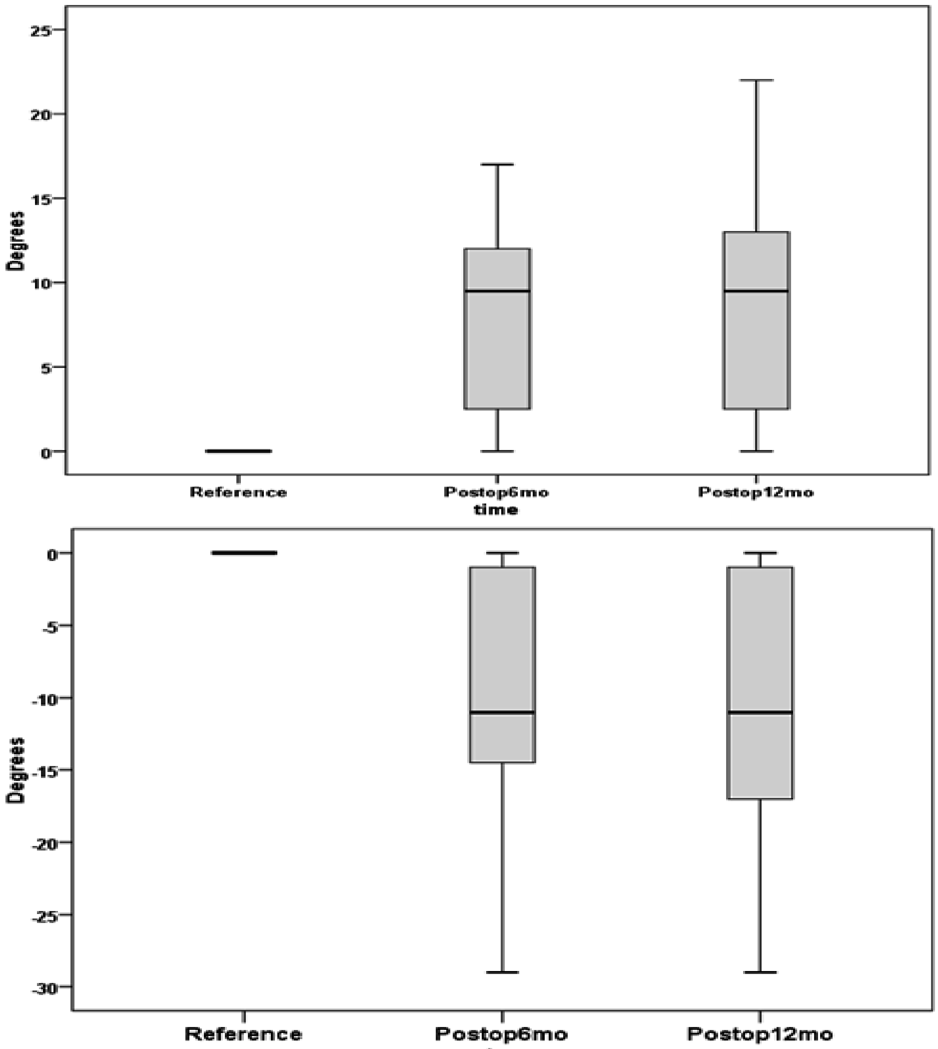

Figure 8: showed the degrees of intraocular lens rotation in postoperative 6 months and 12 months compared with reference at the end of surgery. (The plus value was represented for clockwise rotation and the minus value was for counterclockwise rotation.)

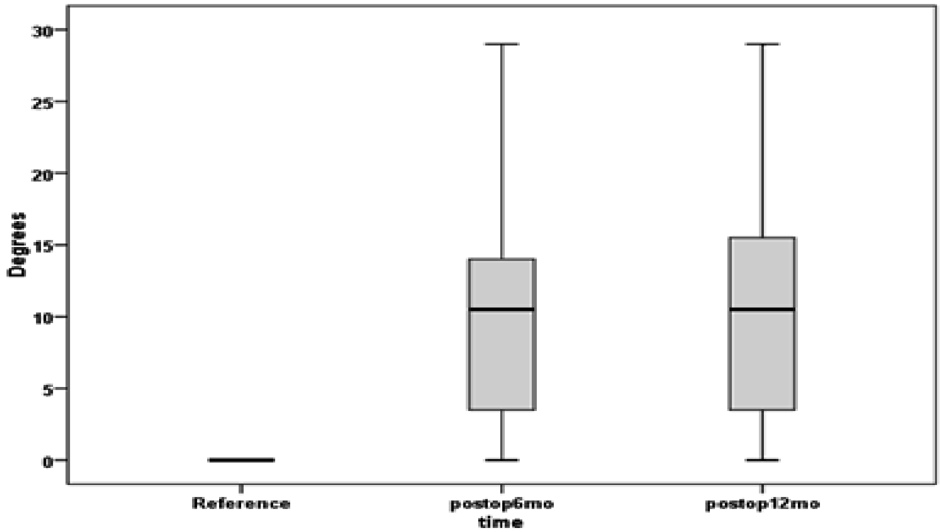

Figure 9: all of intraocular lens rotation was adjusted to positive values in postoperative 6 months and 12 months compared with reference at the end of surgery.

Discussion

Corneal astigmatism contributes the residual refractive error after cataract surgery with non-toric intraocular lens implantation. The toric IOLs is the options of correct corneal astigmatism and provide the better visual outcomes. It provides the better refractive astigmatism and greater distance spectacle independence. Precise IOL calculation measurement, IOL placement, IOL rotational stability are important factors for the best visual outcome.

The use of toric IOLs to correct corneal astigmatism is complicated by rotation of IOL in the capsular bag.

The causes of toric IOL rotational deviation are the IOL rotation itself, secondary by capsular bag shrinkage or fibrosis, IOL capture, haptic displacement, incomplete removal of ophthalmic viscoelastic devices, changes in intraocular pressure[1, 7].

In this study, there was no occurrence of capsular bag fibrosis or IOL capture. In cases of posterior capsular opacity, the YAG-capsulotomy was done before collecting the research data.

The previous study, Alexander et al.[1] found the low level of toric intraocular lens 677TA rotation (mean 2.12 +/- 3.45 degrees; range -2 to +5 degrees). In parts of the toric IOLs in this study, the mean was 10.11 +/- 7.58 degrees and 10.82 +/- 8.28 degrees in postoperative sixth month and one year respectively. Approximately 1 degree of off-axis rotation results in a loss of up to 3.3% of cylinder power for each degree of rotation. The amount of proportion of group 1 in uncorrected distance visual acuity was less than in best-corrected visual acuity because of the residual refractive astigmatism.

The several techniques including the complete OVD clearance after right-axis IOL placement, avoidance of postoperative IOP fluctuations, appropriate capsulorhexis size, IOL design and material can support IOL rotational stability, reduce amount of residual postoperative astigmatism and improve the visual and refractive outcomes.

The toric IOLs power should be calculated from the total corneal astigmatism or the summation of both anterior and posterior corneal astigmatism. The most commonly used keratometry or IOL master devices do not measure posterior corneal power. The posterior corneal curvature which has minimal cylinder power may effect to the residual refractive astigmatism error after cataract surgery with toric IOLs implantation. So the outcomes of toric IOL implantation could be improved by adjusting posterior corneal surface astigmatism using Pentacam Schiempflug imaging devices. The Baylor nomogram (regression analysis of the adjustment of posterior corneal astigmatism) and Barrett toric calculation formula provide an adjusted corneal reflecting a predicting posterior astigmatism based on anterior keratometry, anterior chamber depth (ACD) and axial length[11, 12, 13.]

Conclusion

The toric IOLs 677TA implantation is the good options to correct preexisting astigmatism in cataract surgery. The postoperative refractive astigmatism decreased from the preoperative values and were stable during the 1-year follow-up while the preoperative and postoperative corneal astigmatism were not changed.

Referrence

1.Bachernegg A, Ruckl T, Riha W, Grabner G, Dexl AK. Rotational stability and visual outcome after implantation of a new toric intraocular lens for the correction of corneal astigmatism during cataract surgery. J Cataract Refract Surg 2013;39(9):1390-8.

2.Kessel L, Andresen J, Tendal B, Erngaard D, Flesner P, Hjortdal J. Toric Intraocular Lenses in the Correction of Astigmatism During Cataract Surgery: A Systematic Review and Meta-analysis. Ophthalmology 2016;123(2):275-86.

3.Gyongyossy B, Jirak P, Schonherr U. Long-term rotational stability and visual outcomes of a single-piece hydrophilic acrylic toric IOL: a 1.5-year follow-up. Int J Ophthalmol 2017;10(4):573-8.

4.Koch DD, Jenkins RB, Weikert MP, Yeu E, Wang L. Correcting astigmatism with toric intraocular lenses: effect of posterior corneal astigmatism. J Cataract Refract Surg 2013;39(12):1803-9.

5.Leon P, Pastore MR, Zanei A, Umari I, Messai M, Negro C, et al. Correction of low corneal astigmatism in cataract surgery. Int J Ophthalmol 2015;8(4):719-24.

6.Mohammad RH, Mohammad RE, Espandar G, Javadi MA, Jafarinasab MR, Hashemian SJ, et al. Three Methods for Correction of Astigmatism during Phacoemulsification. J Ophthalmic Vis Res 2016;11(2):162-7.

7.Potvin R, Kramer BA, Hardten DR, Berdahl JP. Toric intraocular lens orientation and residual refractive astigmatism: an analysis. Clin Ophthalmol 2016;10:1829-36.

8.Ventura BV, Wang L, Weikert MP, Robinson SB, Koch DD. Surgical management of astigmatism with toric intraocular lenses. Arquivos Brasileiros de Oftalmologia 2014;77(2):125-31

9.Zhang B, Ma JX, Liu DY, Du YH, Guo CR, Cui YX. Optical performance of toric intraocular lenses in the presence of decentration. Int J Ophthalmol 2015;8(4):730-5.

10.Holladay JT. Visual acuity measurements. J Cataract Refract Surg 2004;30(2):287-90.

11.Park DY, Lim DH, Hwang S, Hyun J, Chung TY. Comparison of astigmatism prediction error taken with the Pentacam measurements, Baylor nomogram, and Barrett formula for toric intraocular lens implantation. BMC Ophthalmol 2017;17(1):156.

12.Sano M, Hiraoka T, Ueno Y, Itagaki H, Ogami T, Oshika T. Influence of posterior corneal astigmatism on postoperative refractive astigmatism in pseudophakic eyes after cataract surgery. BMC Ophthalmol 2016;16(1):212.

13.Zhang B, Ma JX, Liu DY, Guo CR, Du YH, Guo XJ, et al. Effects of posterior corneal astigmatism on the accuracy of AcrySof toric intraocular lens astigmatism correction. Int J Ophthalmol 2016;9(9):1276-82.