ORIGINAL ARTICLE

Vector Analysis, Rotational Stability, and Visual Outcome After Implantation of a Toric IOL

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ABSTRACT

PURPOSE: To evaluate vector analysis, rotational stability, and refractive and visual outcome of a new toric intraocular lens (IOL) for correction of preexisting corneal astigmatism during routine cataract surgery.

METHODS: In this prospective, interventional case series, 30 toric, aspheric Bi-Flex T toric IOLs (Medicontur Medical Engineering Ltd., Inc., Zsámbék, Hungary) were implanted in 20 consecutive patients with topographic corneal astigmatism between 1.50 and 4.00 diopters (D) and evaluated within the first year after implantation. Appropriate IOL-toric alignment was facilitated by combined imaging/eye tracking technology. Postoperative evaluation included refraction and uncorrected and corrected distance visual acuities (UDVA, CDVA). For each visit, photodocumentation in retroillumination was performed to evaluate toric alignment and potential toric IOL rotation. Vector analysis of refractive astigmatism was performed using the Alpins method.

RESULTS: At 12 months postoperatively, a reduction of the refractive astigmatism from 1.93 ± 0.90 D (range: 0.50 to 4.00 D) to 0.28 ± 0.61 D (range: 0.00 to 1.50 D) could be found, with patients achieving a mean UDVA of 0.06 ± 0.16 logMAR (range: -0.18 to 0.40 logMAR; Snellen 20/20). Intraoperative to 12-month postoperative comparison of IOL axis alignment showed low levels of rotation (0.2° ± 2.41°; range: +4° to -5°). Vector analysis showed target induced astigmatism of 0.60 D Ax180°, surgically induced astigmatism of 0.80 D Ax177°, correction index of 1.02 ± 0.25, and a difference vector of 0.30 D Ax82°.

CONCLUSIONS: Implantation of the new Bi-Flex T IOL was a safe, stable, and effective method to correct preexisting regular corneal astigmatism during cataract surgery.

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Corneal astigmatism is a refractive error that negatively affects uncorrected visual acuity, with 15% to 29% of patients with cataract having more than 1.50 diopters (D) of refractive astigmatism (either corneal or lenticular),[1-3] inducing image distortion that results in a decrease in uncorrected visual acuity.[4] Several studies have confirmed the stable, safe, and predictable outcomes for the correction of astigmatism during cataract surgery using toric intraocular lenses (IOLs).[5-12] It is possible to perform a subtraction method to evaluate postoperative astigmatism changes. This method only considers the absolute amount of astigmatism without accounting for the axis of astigmatism. However, astigmatism is a vectorial variable with an associated magnitude and axis, and this vectorial character of astigmatism should be considered.[13-16] The Alpins method is a vectorial analysis that measures the efficacy of an astigmatic treatment.[17,18]

The purpose of this study was to evaluate the rotational stability and the refractive and visual outcome of the new Bi-Flex T toric IOL (Medicontur Medical Engineering Ltd., Inc., Zsámbék, Hungary) for correction of preexisting corneal astigmatism during routine cataract surgery over a period of 12 months.

PATIENTS AND METHODS

Patient Population

Within this prospective, interventional case series, 20 consecutive patients were included and 30 toric, aspheric Bi-Flex

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T toric IOLs were unilaterally or bilaterally implanted after phacoemulsification. Surgeries were performed by one surgeon (GG) between May 2011 and August 2012. All participants gave written informed consent before enrollment. The study was performed in accordance with the tenets of the Declaration of Helsinki and approved by the institutional review board (Ethics Committee of the County of Salzburg). Inclusion criteria were senile cataract and preexisting regular topographic corneal astigmatism between 1.50 and 4.00 D. Exclusion criteria were irregular corneal astigmatism, diabetic retinopathy, iris neovascularization, serious intraoperative complications, congenital eye abnormality, glaucoma, pseudoexfoliation syndrome, amblyopia, uveitis, long-term anti-inflammatory treatment, advanced age-related macular degeneration, retinal detachment, prior ocular surgery, severe corneal and retinal diseases, and eye trauma in the medical history.

Preoperative Assessment

Before surgery, complete medical history was evaluated and all patients underwent a full ophthalmologic examination, including refraction and uncorrected (UDVA) and corrected (CDVA) distance visual acuity measurement. Within this trial, Early Treatment Diabetic Retinopathy charts (Precision Vision, IL) at 4 m under photopic illumination (85 to 100 cd/m^2) were used, by counting the numbers of optotypes identified correctly and converting the results into logMAR values. In addition, intraocular pressure (contact Goldmann tonometry), corneal topography (Keratron; Optikon Ophthalmic Equipment, Rome, Italy), and laser interference biometry (IOLMaster; Carl Zeiss Meditec AG, Jena, Germany) were performed. Preoperative images were taken with the SMI Surgery Guidance unit SG3000 (Sensomotoric Instruments GmbH, Teltow, Germany) for intraoperative imaging/eye tracking, to facilitate the appropriate positioning of the toric IOL. IOL cylinder power and axis placement were calculated using a program available from the IOL manufacturer (http://toriccalculator.net/en/calculator), taking into account the IOLMaster keratometry readings. One eye was calculated with a target refraction of -3.00 D at the request of the patient for remaining postoperative myopia. All other eyes were calculated for emmetropia. No surgically induced astigmatism (SIA) for the incision was assumed preoperatively because of the corneoscleral tunnel incision used.

IOL Implanted

AQ1 The implanted Bi-Flex T toric IOL has an overall diameter of 13.0 mm, double loop haptics, and an optic diameter of 6 mm without haptic angulations. The refractive index of the optic material at 23°C is 1.46. The toric IOL is a single-piece IOL made of hydrophilic acrylic co-polymer with integrated covalently bound benzophenone as ultraviolet absorbent. The toric component of the IOL is located on the posterior surface of the lens optic. The torus is marked with two marks at the edge of the toric IOL optic. The toric IOL is available with cylinder powers of 1.50 to 12.00 D (monotoric) and up to 27.00 D (bitoric; convex-concave technology). This toric IOL is aspheric with neutral asphericity approach with sharp edge following 360° to prevent migration of lens epithelial cells and therefore prevent posterior capsule opacification formation (package insert; Medicontur Medical Engineering Ltd., Inc., Zsámbék, Hungary).

Surgical Technique

Superior corneoscleral tunnel (incision width: 2.3 mm) and circular curvilinear capsulorhexis were performed in all cases with a planned size of 5 mm. Cataract was removed by phacoemulsification, toric IOLs were folded and implanted in the bag, and sutureless wound closure was performed in all cases. After implantation and ophthalmic viscoelastic device removal, the toric IOL was rotated to its final position by exactly aligning the toric reference according to the intraoperative imaging/eye tracking unit. In this study, SMI's Surgery Guidance solution SG3000 was used to align the toric IOL to the correct position. It consists of the SMI Reference Unit taking reference measures including keratometry readings and high-definition images of the eye and the SMI Surgery Pilot providing customizable digital marks overlaid live on the patient's eye during surgery. The SMI Surgery Pilot provides the surgeon with data directly displayed in the oculars of the microscope. The equipment provides automated visual guidance for the surgeon without manual markers. Based on a preoperative reference image, the unit allows for automatic registration and control of the eye position under the surgical microscope. At the end of surgery, an intraoperative picture in retroillumination was taken to document the torus position.

Postoperative Assessment

Postoperative examinations were performed 1 day, 1 week, and 1, 3, and 12 months postoperatively. The postoperative examinations included the measurement of refraction (UDVA, CDVA) and intraocular pressure. Slit-lamp examination, subjective refraction, and photography of the IOL in retroillumination were also performed. Photoshop Software for Windows (Adobe Systems Incorporated, San Jose, CA) was used to evaluate the retroillumination pictures. Rotation of the toric

IOL was evaluated as follows. Postoperative lens position was compared to the intended torus position, as indicated by the SMI Surgery Pilot. A rotation clockwise was counted as negative and counterclockwise as positive rotation. Mean absolute rotation was assessed for different time periods. Every rotation (regardless if clockwise or counterclockwise) was regarded as positive rotation and the rotation from one time point to another (end of operation to day 1; day 1 to week 1; week 1 to month 1; month 1 to month 3; month 3 to month 12) was plotted to check if a significant rotation could be found within a certain time period. A rotation between the intended torus position and the first postoperative visit at day 1 was regarded as misalignment, and between day 1 and the following visits as toric IOL rotation. UDVA data were calculated from the 29 eyes targeted for postoperative emmetropia, whereas all 30 eyes were available for CDVA calculation.

Vector Analysis

Vector analysis and graphical displays were performed using the Alpins method, facilitated by the ASSORT program version 5.04 (Assort Pty., Ltd., Victoria, Australia). Preoperative and 12-month postoperative values for manifest refraction and topographic astigmatism were analyzed. Three fundamental vectors and the relationship among them were examined. First, target induced astigmatism (TIA) was defined as the astigmatic change in magnitude and axis the surgery was intended to correct. Therefore, actual measured preoperative corneal topographic astigmatism was used. Second, the difference vector was defined as the induced astigmatic change by magnitude and axis that would enable the initial surgery to achieve its intended target. That means the difference vector is the actual measured postoperative refraction remaining after treatment. Third, SIA was defined as the amount and axis of astigmatism the surgery actually induced. The SIA is a calculated quantity by subtracting the phacoemulsification-adjusted preoperative corneal astigmatism from the postoperative refractive cylinder calculated to the corneal plane.[17,18] Additionally, the correction index was examined.

Furthermore, relationships between these three fundamental vectors were calculated and defined as follows: (1) correction index calculated by determining ratio of SIA to TIA (correction index is preferably 1.0; if correction index > 1.0 overcorrection occurred and if correction index < 1.0 undercorrection occurred); (2) magnitude of error is the arithmetic difference between magnitudes of SIA and TIA (magnitude of error > 0 indicates overcorrection and magnitude of error < 0 undercorrection); (3) angle of error is the angle de-

TABLE 1
Preoperative Demographics (20 Patients, 30 Eyes)

Demographic	Value
Age (y)	
Mean ± SD	63.9 ± 11.1
Range	37 to 81
Sex (N)	
Female	12
Male	8
Operated eye (N)	
Right	5
Left	5
Both	10
Preoperative refractive astigmatism (D)	
Mean ± SD	1.93 ± 0.90
Range	0.50 to 4.00
Preoperative topographic astigmatism (D)	
Mean ± SD	2.36 ± 0.50
Range	1.53 to 3.28
Preoperative keratometric astigmatism (D)	
Mean ± SD	3.29 ± 0.84
Range	1.94 to 4.74
MRSE (D)	
Mean ± SD	-1.21 ± 2.83
Range	-6.38 to +4.50
Preoperative UDVA (logMAR)	
Mean ± SD	0.97 ± 0.56
Range	0.10 to 2.00
Preoperative CDVA (logMAR)	
Mean ± SD	0.44 ± 0.31
Range	0.00 to 1.30
IOL Power (sphere)	
Mean ± SD	18.50 ± 4.58
Range	12.50 to 29.00
IOL Power (cylinder)	
Mean ± SD	2.98 ± 0.87
Range	1.50 to 4.50
Axial length (mm)	
Mean ± SD	23.75 ± 1.67
Range	20.57 to 26.51

SD = standard deviation; D = diopters; MRSE = mean refractive spherical equivalent; UDVA = uncorrected distance visual acuity; CDVA = corrected distance visual acuity; IOL = intraocular lens

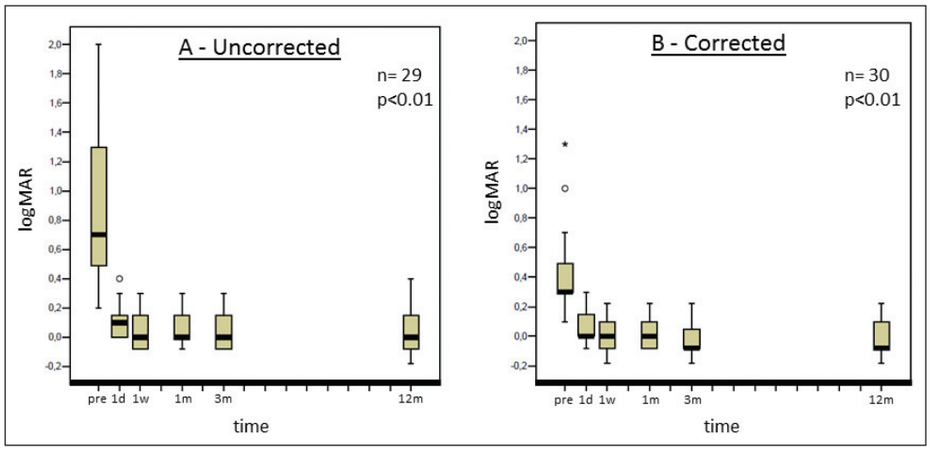

Figure 1. (A) Uncorrected and (B) corrected distance visual acuity over time after phacoemulsification and toric intraocular lens implantation.

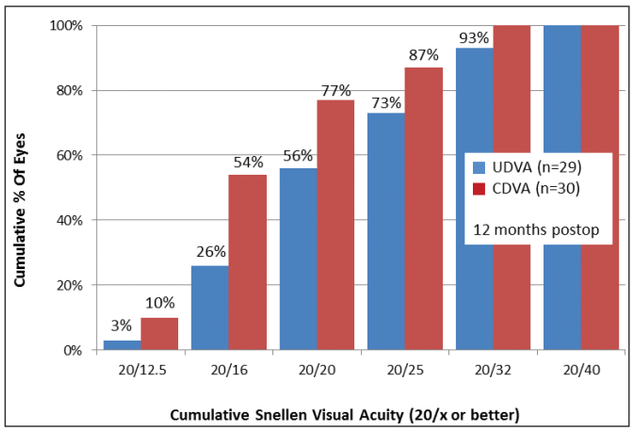

Figure 2. Uncorrected (UDVA) and corrected (CDVA) distance visual acuity 12 months after toric intraocular lens implantation.

scribed by the vectors of SIA versus TIA (angle of error > 0: achieved correction axis is counterclockwise to where it was intended; angle of error < 0: achieved correction is clockwise to its intended axis); (4) index of success is calculated by dividing difference vector by TIA, representing a relative measure of success (index of success is preferably 0).

Statistical Analysis

Statistical analysis was performed using SPSS for Windows software (version 15.0; SPSS, Inc., Chicago, IL). The mean values and standard deviations were calculated for every parameter. Normal distribution of all data samples was first checked using the Kolmogorov–Smirnov test. Parametric analysis was possible. To analyze the data from preoperative and postoperative examinations and between consecutive postoperative visits in the IOL group, one-way analysis of variance for repeated measures was used. If sphericity could not be assumed, Greenhouse–Geisser estimates were used as a correction factor. Post hoc comparisons were performed using the Bonferroni procedure. In all instances, a *P* value of less than .05 was considered statistically significant. If variances were not homogeneous (checked by the Levene test), Tamhane post hoc analysis was used. When parametric analysis was not possible, the Kruskal–Wallis test was used to compare the IOL groups, with a *P* value of less than .05 considered statistically significant. For post hoc analysis, the Mann–Whitney test with Bonferroni adjustment was used to avoid an experimental error rate.

RESULTS

This study enrolled 30 eyes of 20 consecutive patients. Demographic data and implanted toric IOL powers are shown in **Table 1**.

Visual Acuity

UDVA (preoperative: 0.97 ± 0.56 logMAR, range: 0.10 to 2.00 logMAR, Snellen 20/200) increased significantly to 0.05 ± 0.12 logMAR (range: -0.18 to 0.30 logMAR, Snellen 20/22.5, $P < .01$) after 3 months and reached 0.06 ± 0.16 logMAR (range: -0.18 to 0.40 logMAR, 20/23, $P < .01$) at the 12-month control visit (**Figures 1A-2**).

CDVA (preoperative: 0.44 ± 0.31 logMAR, range: 0.00 to 1.30 logMAR, Snellen 20/55) increased significantly to -0.01 ± 0.10 logMAR (range: -0.18 to 0.22 logMAR, Snellen 20/20, $P < .01$) after 3 months and reached 0.01 ± 0.12 logMAR (range: -0.18 to 0.22 logMAR, Snellen 20/20, $P < .01$) at the 12-month control visit (**Figures 1B-2**). There was only a 0.5-line difference between the UDVA and the CDVA postoperatively, indicating a good refractive result. UDVA and CDVA values stayed stable during the 12-month follow-up period (**Figure 1**).

Refraction

Mean spherical equivalent (SE) did not change significantly from preoperative values (-1.21 ± 2.83 D,

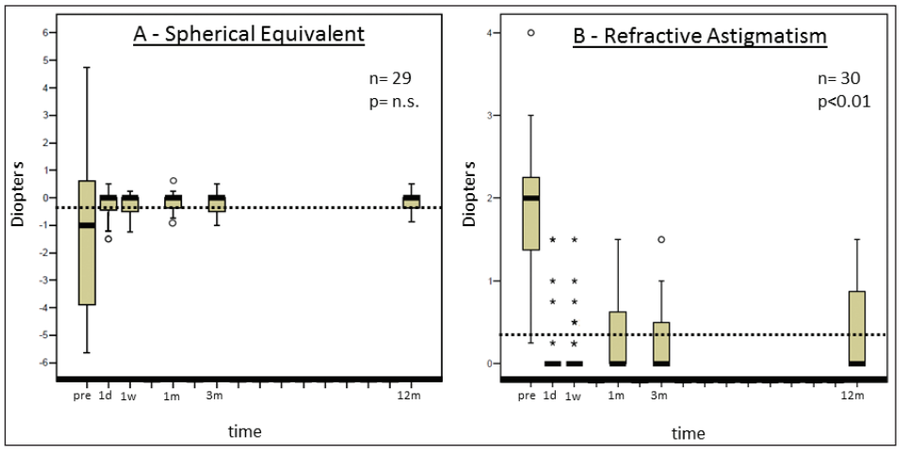

Figure 3. Stability of (A) spherical equivalent and (B) refractive astigmatism over time after phacoemulsification and implantation of the trial toric intraocular lens. The dashed horizontal line in A indicates the calculated mean postoperative target refraction (spherical equivalent). The dashed horizontal line in B indicates the calculated mean postoperative remaining refractive astigmatism (cylinder).

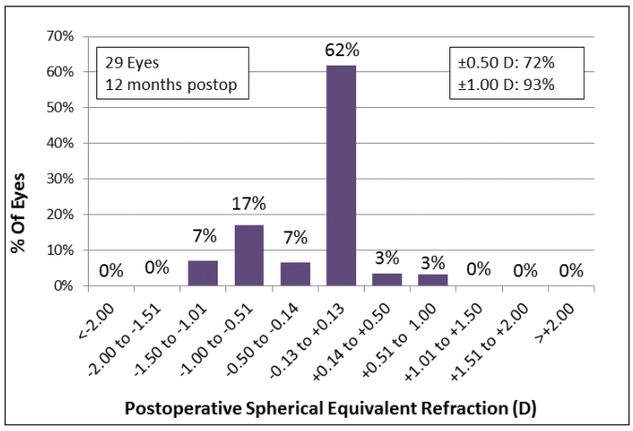

Figure 4. Spherical equivalent refractive accuracy 12 months after toric intraocular lens implantation.

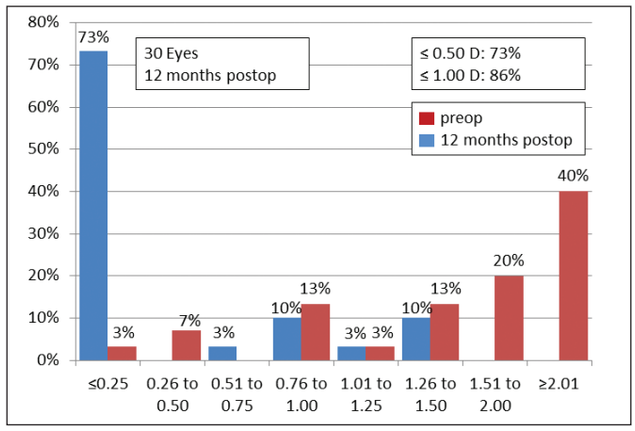

Figure 5. Comparison of preoperative and 12-month postoperative refractive astigmatism after toric intraocular lens implantation.

range: -6.38 to +4.50 D) and reached -0.20 ± 0.46 D (range: -1.25 to 0.63 D) at 12 months postoperatively (**Figure 3A**). Seventy-two percent (21 of 29 eyes targeted for postoperative emmetropia) were within ±0.50 D of emmetropia, and 93% (27 of 29 eyes) were within ±1.00 D (**Figure 4**).

Refractive astigmatism at the 12-month visit (0.28 ± 0.61 D) compared to the calculated remaining astigmatism (0.38 ± 0.52 D) did not show any significant difference (**Figure 3B**). Postoperatively, 73% (22 of 30 eyes) had refractive astigmatism 0.50 D or less, 86% (26 of 30 eyes) had 1.00 D or less, and 100% (30 of 30 eyes) had 1.50 D or less (**Figure 5**).

Preoperative topographic astigmatism (2.39 ± 0.54 D) showed no significant difference compared to the 3-month postoperative topographic values (2.10 ± 0.72 D).

Vector Analysis

Vector analysis was performed at the 12-month control visit. **Table 2** summarizes astigmatism analysis results using the Alpins method and **Figure A** (available in the online version of this article) shows vector graphs of SIA, TIA, difference vector, and correction index. Vector data were specified as vector with magnitude and direction on one hand and arithmetic values on the other hand (vector magnitude and axis are shown within brackets). The mean magnitude of TIA was 2.35 ± 0.66 D (0.60 D Ax180°), whereas the mean magnitude of SIA was slightly higher 2.39 ± 0.73 D (0.80 D Ax177°), indicating a slight overcorrection. The remaining difference vector was 0.41 ± 0.45 D (0.30 D Ax82°). The mean correction index (ratio SIA to TIA; preferably 1), was 1.02 ± 0.25, reflecting the previously mentioned slight overcorrection. The mean magnitude of error was slightly positive (0.08 ± 0.38; overcorrection). Index of success as a relative measure of success (preferably 0) was 0.22 ± 0.27 and the mean angle of error was slightly positive (12 months: 2.72° ± 6.78°).

Misalignment and IOL Rotation

When comparing the intended toric IOL axis position to the position of the last follow-up, a mean rota-

TABLE 2
Publications Reporting Vector Analysis After Implantation of a Monofocal Toric IOL[a]

Study	IOL Model (Manufacturer)	Follow-up (months)	Eyes/ Patients (n)	UDVA (logMAR)	Vector Analysis				Refractive Cylinder (D)	IOL Rotation (°)
					TIA	SIA	DV	CI		
Current study	Bi-Flex T (Medicontur)	12	30/20	0.06 ± 0.16	2.35 ± 0.66 (0.6Ax180°)	2.39 ± 0.73 (0.8Ax177°)	0.41 ± 0.45 (0.3Ax82°)	1.02 ± 0.25	0.28 ± 0.61	-0.2 ± 2.41
Alió et al. (2011)[12]	AcrySof toric (Alcon)	6	27/21	0.16 ± 0.15	2.80 ± 0.79 (NR)	2.49 ± 0.91 (NR)	0.91 ± 0.45 (NR)	0.87 ± 0.21	-0.94 ± 0.40	5.06 ± 4.21
Alió et al. (2010)[13]	Acri.Comfort 646 TLC (Zeiss)	3	21/12	0.65 ± 0.22 (decimal)	4.54 ± 2.72 (1.20Ax2°)	4.18 ± 2.66 (0.99Ax1°)	0.47 ± 0.61 (0.23Ax8°)	0.91 ± 1.23	-0.45 ± 0.63	-1.75 ± 2.93
Visser et al. (2012)[14]	AcrySof toric (Alcon)	12	35/20	0.12 ± 0.11	2.82 ± NR (1.35Ax7°)	NR (1.53Ax7°)	NR (0.18Ax10°)	1.00 ± NR	0.37 ± 0.36	NR
Visser et al. (2011)[15]	AcrySof toric (Alcon)	3	26/18	NR	2.17 ± 0.82 (1.04Ax5°)	2.18 ± 1.04 (1.25Ax3°)	0.46 ± 0.40 (0.24Ax81°)	0.99 ± 0.27	NR	2.5 ± 2.7

IOL = intraocular lens; UDVA = uncorrected distance visual acuity; NR = not reported; D = diopter; TIA = target induced astigmatism; SIA = surgically induced astigmatism; DV = difference vector; CI = correction index
[a]*Visual acuity, cylinder, CI, and IOL rotation presented in mean ± standard deviation. TIA, SIA, and DV are shown in arithmetic values (mean ± standard deviation) and mean vector values (in parenthesis).*

tion of 0.2° ± 2.41° (range: -5° to +4°) could be seen at the 12-month control visit (**Figure B,** available in the online version of this article). The magnitude of rotation (regarded as misalignment) could be seen within the first 24 hours, whereas only minimal rotation could be seen within the remaining follow-up between 1 day, 3 months, and 12 months (**Figure B**).

The median misalignment (ie, absolute difference in toric IOL axis between intended placement and measured IOL axis 1 day after surgery) was 0° (range: 0° to -5°; **Figure A**). The alignment was within ±2° of the intended axis in 27 of 30 eyes (90%). The median IOL rotation between 1 day and 12 months was also 0°. No IOL rotated more than 2° within this time period (**Figure B**). There were no statistically significant differences in the intended, 1-day, and 12-month IOL axes (repeated-measure analysis of variance with Bonferroni post test).

COMPLICATIONS

Two IOLs had a partially broken double loop haptic after injection in the posterior chamber with the shooter used within this trial (Medicontur MedJet B injector; Medicontur Medical Engineering Ltd., Inc.) but required no secondary procedure because of stability within the capsular bag and the fact that no clinically relevant rotation occurred within the follow-up period. No eye had other intraoperative or postoperative complications, and no patient needed secondary procedures because of rotational instabilities or torus misalignment. In addition, no eye required a Nd:YAG capsulotomy up to the last postoperative visit.

DISCUSSION

Different methods can be used to accurately determine the position of a toric IOL. Weinand et al.[19] and Becker et al.[20] analyzed digital and conventional photographs, taken preoperatively and postoperatively through the slit lamp and operating microscope. Analyzing photographs in retrograde illumination has become widely used in evaluating the centration and axial positioning of a toric IOL. This proven method was also applied in the current study, when comparing the intended torus position to the position of the toric IOL during the different follow-up visits. We could measure an IOL rotation of 0.2° ± 2.41° (range: -5° to +4°) 1 year after implantation, which is consistent with other published trials reporting on vector analysis and rotational stability after monofocal toric IOL implantation (mean values between -1.75° ± 2.93° and 5.06° ± 4.21°; **Table 2**).[13,14,16] It is reasonable to consider that a misalignment of less than 5° might be attributed to observational errors when a slit-lamp photographic

technique is used for axis measurement; these errors might be related to reference marking and reading and preoperative keratometry readings other than IOL rotation, as mentioned in the literature.[21,22]

Postoperative cylinder values decreased significantly and remained stable over time (mean preoperative: 1.93 ± 0.90 D; mean 12-month postoperative: 0.28 ± 0.61 D), being consistent with results of prior studies with other IOL types.[13-16] UDVA is one of the most important parameters of success for patients, and can be significantly improved by implanting toric IOLs. In our study, mean UDVA was 20/40 or better in 100% of patients. The UDVA in the current study (mean: 0.06 ± 0.16 logMAR, Snellen 20/22.5) compares with reports of outcomes with other toric IOLs. Alió et al.[13] reported a UDVA of 0.16 ± 0.15 logMAR after implantation of the AcrySof Toric IOL (Alcon Laboratories, Inc., Fort Worth, TX) and 0.65 ± 0.22 decimal after implantation of the Acri.Comfort 646 TLC IOL (Carl Zeiss Meditec),[14] whereas Visser et al.[15] identified a mean UDVA of 0.12 ± 0.11 logMAR after implantation of the AcrySof Toric IOL. Only a 0.5-line difference between the mean UDVA (0.06 ± 0.16 logMAR; Snellen 20/22.5) and the mean CDVA (0.01 ± 0.12 logMAR, Snellen 20/20) 12 months after implantation of the Bi-Flex T toric IOL could be seen, indicating a good refractive result. SIA showed a negligible effect on topographic corneal astigmatism due to the above-mentioned corneoscleral tunnel.

Because rotation of a toric IOL causes remaining astigmatism, vector analysis was applied to evaluate changes in refractive astigmatism, considering magnitude and orientation of this variable. To our knowledge, this is the first report of the Bi-Flex T toric IOL evaluated by vector analysis. Calculation of three fundamental vectors (TIA, SIA, and difference vector) constitutes the basis of the Alpins vector analysis method.[17,18] In an ideal correction, TIA and SIA would be identical and the resulting difference vector would be 0. Previous studies of vector analysis following implantation of other toric IOL models reported results between slight undercorrection[13,14,16] and the ideal achieved correction.[15] In the current study, the TIA was lower than the SIA, indicating a slight overcorrection. The correction index of 1.02 and the positive magnitude of error of 0.08 ± 0.38 also reflect the slight overcorrection of the achieved astigmatic treatment. A possible explanation for overcorrection could be the underestimation of the toric IOL power at corneal plane by the manufacturers. As previously described in the literature, this underestimation can explain the remaining astigmatism.[23] The angle of error displays the misalignment of treatment. The positive value of angle of error indicates a slight mean counterclockwise rotation to its intended axis and is consistent with reported rotation in previous studies mentioned above.[13-16] The mean absolute angle of error was slightly higher because the rotation was measured by picture comparison. Further examinations comparing both angle of error and measured IOL rotation should be performed to reach a better understanding of its correlation and clinical interpretation.

The Bi-Flex T toric IOL was stable in the capsular bag after 1 day, with minimal rotation from 1 day to 12 months. Vector analysis showed a good correlation of TIA and SIA vectors with a tendency to minimal overcorrection. Only a 0.5-line difference between the mean UDVA and the mean CDVA could be seen postoperatively, confirming the efficacy of the study lens to correct both corneal astigmatism and cataract within a single surgical procedure.

AUTHOR CONTRIBUTIONS

Study concept and design (AKD, GG); data collection (AB, GJ, TR, CS); analysis and interpretation of data (AB, AKD, GG, CS); writing the manuscript (AB, AD); critical revision of the manuscript (AKD, GG, GJ, TR, CS); statistical expertise (AB, AKD); administrative, technical, or material support (GG); supervision (AKD, GG, CS)

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AUTHOR QUERIES

General

Per the Editor, the title has been changed. Please include two to three words describing how the IOL is different in the title.

Per the Editor, "torus" is not a familiar term and should be removed and replaced throughout or defined early in the Introduction or Methods.

Per the Editor, original Figures 6 and 7 will only appear in the online version of the article as Figures A and B.

Per the Editor, portions of the Discussion have been removed. Please verify the order of all references and citations for accuracy.

Per the Editor, please change the "Ax" vector marking to more conventional terminology both in text and in Figure A/original Figure 6.

AQ1

Per the Editor, please consider providing an image of the Bi-Flex T toric IOL. This image will only be included in the online version of the article.

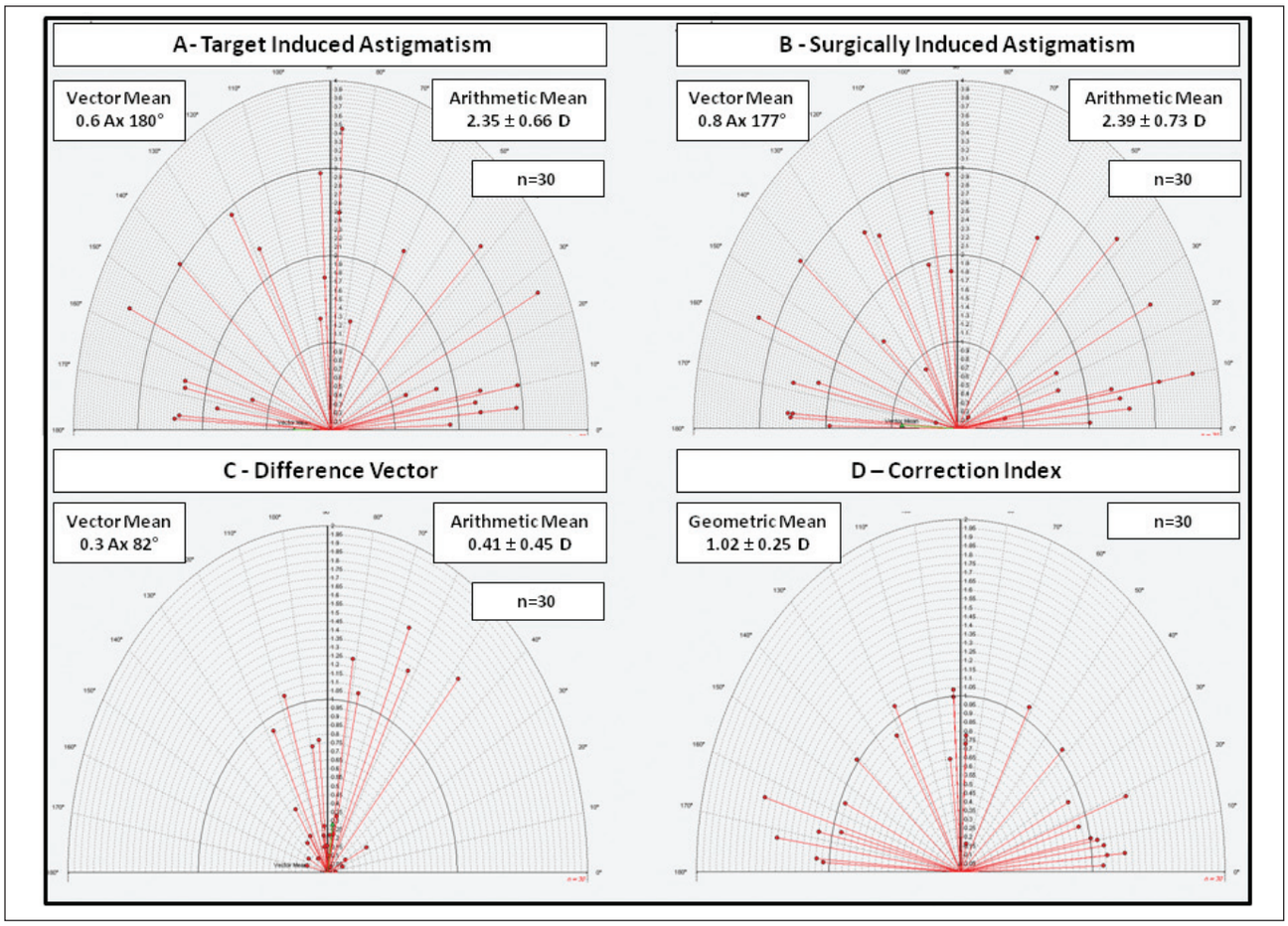

Figure A. Vector analysis of refractive astigmatism 12 months after toric intraocular lens implantation.

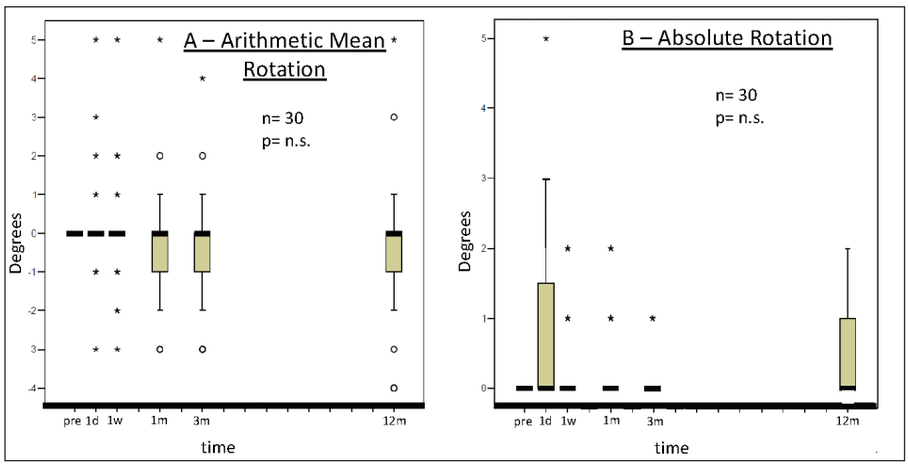

Figure B. (A) Intraocular lens rotation in relation to the torus position at the end of surgery (rotation clockwise was regarded as negative and counterclockwise as positive). (B) Rotation between different follow-up visits (every rotation was regarded as positive whether rotation was clockwise or counterclockwise).