14 Multifocal Intraocular Lenses: AT LISA Tri Toric 939 M/MP

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The presence of more than 1.00 D of astigmatism in eyes implanted with diffractive multifocal IOLs has been shown to compromise corrected distance and distance-corrected near visual acuities. This was the reason that led to the development of multifocal toric IOLs. These implants have been demonstrated to provide good visual outcomes at different distances [1–7]. Recently, trifocal toric IOLs have been developed as an option to compensate for different levels of preexisting corneal astigmatism after cataract surgery and to simultaneously provide complete restoration of visual function.

14.1 Intraocular Lens

The new trifocal toric 939 M/MP (Fig. 14.1) is based on the optical design of the trifocal notoric and additionally incorporates a bitoric cylinder correction. Bitoricity means that the toric surface is distributed over both the anterior and posterior surfaces and, as an advantage over monotoric designs, provides a larger usable optic and the ability to produce better modulation transfer functions (MTFs) for higher cylinders. The multifocal optic is on the front side and the toricity is spread over both sides, which is different from the bifocal toric (multifocal on back side, toricity on front side). This trifocal toric IOL is a diffractive trifocal preloaded IOL with a 6.0 mm biconvex optic and an overall length of 11.0 mm. It is made of foldable hydrophilic acrylate with a water content of 25% and a hydrophobic surface with the refractive index of 1.46. Aspheric optics correct spherical aberration of typical corneas, and the asphericity of this lens is - 0.10 um. It has a 4-haptic design with an angulation of 0 degrees and an additional 360 degrees anti-posterior capsule opacification ring on the optic. The lens is trifocal within a lens diameter of 4.3 mm, and bifocal in the outer 4.3 mm to 6.0 mm of the diameter. The add powers within the 4.3 mm diameter are +3.33 D near add and + 1.66 D intermediate add at the IOL plane. The add power between the 4.3 and 6 mm diameter is +3.75 D (equal to the bifocal AT LISA). The lens is available in 2 types: a preloaded MP type from a spherical power of −10.0 D to +28.0 D in 0.5 D increments and a cylindrical power of +1.0 D to +4.0 D in 0.5 D increments, and a non-preloaded M type from a spherical power of +28.5 D to +32.0 D in 0.5 D increments and a cylindrical power of +4.5 D to +12.0 D in 0.5 D increments. The manufacturer's A-constant for this lens is 118.8. The easiest way to calculate the trifocal toric IOL is by using the manufacturer's online calculator ZCALC [8].

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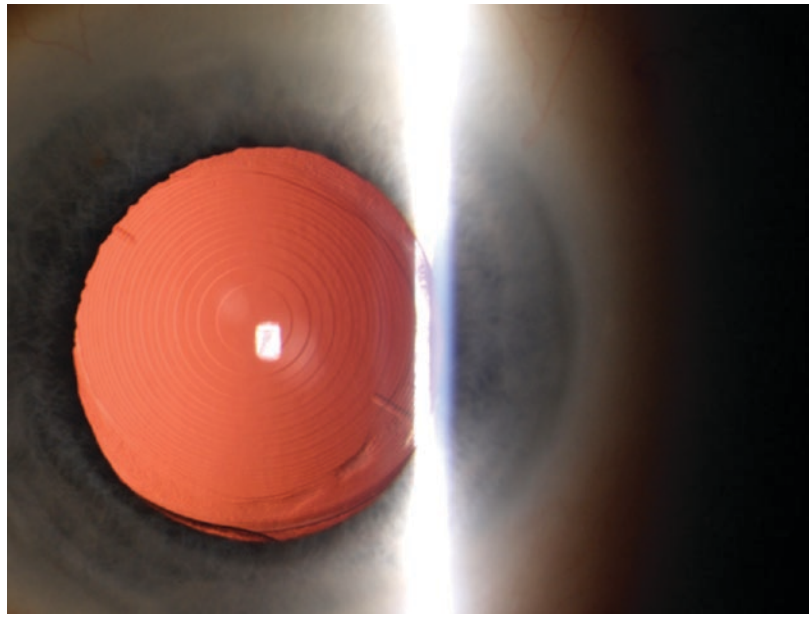

Fig. 14.1 Slitlamp image of trifocal toric IOL

14.2 Preoperative and Postoperative Examination

This prospective consecutive study included 30 eyes of 16 patients. In 14 patients bilateral implantation was performed, and in 2 patients unilateral implantation was performed. Inclusion criteria were patients with cataract or presbyopic patients suitable for refractive lens exchange with regular corneal astigmatism greater than 1.25 D. Exclusion criteria were patients with a history of glaucoma or retinal detachment, corneal disease, irregular corneal astigmatism, abnormal pupils, macular degeneration or retinopathy, neuroophthalmic disease, active intraocular inflammation requiring treatment in the previous 1 year, or previous ocular surgery. Before the surgery, complete ophthalmologic examinations were performed, including refraction, keratometry, uncorrected distance visual acuity (UDVA) and corrected distance visual acuity (CDVA) using Early Treatment of Diabetic Retinopathy Study (ETDRS) charts, uncorrected intermediate visual acuity (UIVA) and corrected intermediate visual acuity (CIVA) at 66 cm (modified ETDRS for Europe-wide use for near and intermediate distance recordings, Precision Vision) and 80 cm (Logarithmic Visual Acuity Charts, calibrated for testing at 80 cm, Precision Vision), uncorrected near visual acuity (UNVA) and corrected near visual acuity (UCVA) at 33 cm (modified ETDRS for Europe-wide use for near and intermediate distance recordings, Precision Vision) and 40 cm (Logarithmic Visual Acuity Chart, ETDRS 2000, calibrated for testing at 40 cm, Precision Vision), distance-corrected near visual acuity (DCNVA) (33 and 40 cm) and distance-corrected intermediate visual acuity (DCIVA) (66 and 80 cm), Goldmann applanation tonometry, slitlamp examination, corneal topography, ocular aberrometry (both OPD-scan III, Nidek Co., Ltd.), biometry (IOLMaster version 4.3, Carl Zeiss Meditec AG), and fundoscopy. Zernike coefficients including tilt (Z1, −1, Z 1,1), astigmatism (Z2, −2, Z 2,2), trefoil (Z3, −3, Z 3,3), coma (Z3, −1, Z 3,1), tetrafoil (Z4, −4, Z 4,4), and spherical aberration (Z4,0) for ocular, corneal, and internal aberrations were measured in 5.0 mm pharmacologically dilated pupils. Postoperatively, patients were evaluated the day after surgery, as well as at 1 and 3 months after surgery. The postoperative examination protocol was identical to the preoperative protocol, with the additional evalu-

ation of the binocular distance-corrected defocus curve at 3 months postoperatively to evaluate the range of functional vision, monocular distance-corrected contrast sensitivity under photopic (85 candelas [cd]/m) and mesopic conditions (3 cd/m^2) (CSV-1000, Vector Vision), IOL rotation and aberrations with the Refractive Power/Corneal Analyzer, quality of life with the National Eye Institute Visual Functioning Questionnaire 14 (NEI VFQ-14) [9] including an appendix of optional additional questions, and the halo and glare perception with a simulator (Halo and Glare Simulator, Eyeland Design Network GmbH). For the evaluation of the defocus curve, patients wore the correction providing the best CDVA in both eyes and the ETDRS charts were used at a distance of 4 m. Different levels of defocus were introduced in 0.5 D steps from +1.00 D to −4.00 D, and visual acuity values were then recorded. All of these data were then represented in a Cartesian graphic display, with the X-axis showing the levels of defocus and the Y-axis the visual acuity achieved. In addition to these analyses, a vector analysis using the Assort software (Assort Pty, Ltd.) was performed to analyze the effectiveness of the astigmatic correction based on the Alpins vector method [10]. It consists of the calculation of the following vectors and parameters: targeted induced astigmatism (TIA), which is the vector of the intended change in cylinder for each treatment; surgically induced astigmatism (SIA), which is the vector of the real change achieved; difference vector, which is the additional astigmatic change that would enable the initial surgery to achieve its intended target; magnitude of error, which is the arithmetic difference between the magnitudes of the SIA and TIA; angle of error, which is the angle described by the vectors of SIA and TIA; correction index, which is the ratio of SIA to the TIA (ideal value is 1, with overcorrection for values greater than 1 and undercorrection for values less than 1); torque, which is the amount of astigmatic change induced by the SIA attributable to nonalignment of the treatment that was ineffective in reducing astigmatism at the intended meridian but caused rotation and a small increase in the existing astigmatism; and flattening effect, which is the amount of astigmatism reduction achieved by the effective proportion of the SIA at the intended meridian (a flattening effect was considered positive and a steepening effect was considered negative).

14.3 Surgery

Sutureless microincision phacoemulsification 1.8 mm from the temporal side was performed. In all cases, topical anesthesia and mydriatic drops were administered to the patient prior to the surgical procedure. After capsulorhexis creation and phacoemulsification, the IOL was inserted into the capsular bag through the main correction index using the Bluemixs 180 injector (MP) (Carl Zeiss Meditec AG) and in 4 cases (M type) using a Viscoject-Bio injector (Medicel AG). Preoperatively, with the patient in the supine position, three limbal reference marks at the 3, 6, and 9 o'clock positions were made with a marker, avoiding cyclorotations during surgery. Steep corneal meridian (IOL position) was marked with sterile Mendez gauge. After IOL implantation, the ophthalmic viscosurgical device under the IOL was completely aspirated using bimanual irrigation/aspiration cannulas, avoiding postoperative IOL rotation; afterward IOL was rotated to the precise position. At the end of the surgery, IOL alignment was rechecked with a Mendez gauge.

14.4 Visual Acuity and Refraction

A significant improvement was observed postoperatively in logMAR UDVA, CDVA, UNVA (33 and 40 cm), DCNVA (33 and 40 cm), UIVA (66 and 80 cm), and DCIVA (66 and 80 cm) ($p \leq 0.01$) (Table 14.1). Likewise, as expected, a significant decrease in the refractive cylinder was observed postoperatively ($p \leq 0.01$) (Table 14.1). All eyes had a postoperative refractive cylinder below 1 D, and 80% of eyes (24) had a postoperative manifest astigmatism of 0.50 D or below. Regarding postoperative manifest sphere, 100% and 83.3% of eyes (25) showed a 3-month postoperative value within ±1.0

Table 14.1 Preoperative and postoperative visual conditions of patients included in this study

Mean (SD) range				
	Preoperative	1 Month	3 Months	*P* value, preoperative to 3 Months
LogMAR UDVA	0.78 (0.38)	0.06 (0.12)	0.03 (0.11)	<0.01
	0.00, 1.40	−0.10, 0.30	−0.10, 0.30	
Sphere (D)	−0.39 (3.68)	−0.29 (0.48)	−0.28 (0.41)	0.25
	−7.50, +5.75	−1.25, +0.50	−1.00, +0.50	
Cylinder (D)	−1.80 (1.65)	−0.40 (0.32)	−0.35 (0.27)	<0.01
	−6.50, 0.00	−1.00, 0.00	−0.75, 0.00	
SE	−0.50 ± 3.30	−0.50 ± 0.48	−0.45 ± 0.42	0.65
	−7.50, +4.50	−1.38, +0.25	−1.13, +0.50	
LogMAR CDVA	0.10 (0.19)	0.02 (0.10)	0.00 (0.09)	0.01
	−0.10, 0.80	−0.10, 0.30	−0.10, 0.20	
LogMAR UNVA (33 cm)	0.83 (0.29)	0.23 (0.09)	0.23 (0.07)	<0.01
	0.10, 1.30	0.10, 0.40	0.10, 0.40	
LogMAR CNVA (33 cm)	0.29 (0.18)	0.22 (0.09)	0.20 (0.09)	<0.01
	0.10, 0.90	0.10, 0.40	0.00, 0.40	
LogMAR DCNVA (33 cm)	0.64 (0.14)	0.23 (0.08)	0.23 (0.08)	<0.01
	0.40, 0.90	0.10, 0.40	0.10, 0.40	
LogMAR	0.84 (0.26)	0.23 (0.12)	0.16 (0.09)	<0.01
UNVA (40 cm)	0.20, 1.30	−0.10, 0.40	−0.10, 0.30	
LogMAR CNVA (40 cm)	0.26 (0.22)	0.21 (0.13)	0.15 (0.09)	0.01
	−0.10, 0.90	−0.10, 0.40	−0.10, 0.30	
LogMAR DCNVA (40 cm)	0.55 (0.17)	0.24 (0.12)	0.16 (0.10)	<0.01
	0.20, 0.80	0.00, 0.40	−0.10, 0.30	
LogMAR UIVA (66 cm)	0.77 (0.37)	0.11 (0.10)	0.09 (0.11)	<0.01
	0.20, 1.50	−0.10, 0.30	−0.10, 0.30	
LogMAR CIVA (66 cm)	0.12 (0.20)	0.11 (0.11)	0.08 (0.1)	0.71
	−0.10, 0.70	−0.10, 0.30	−0.10, 0.30	
LogMAR DCIVA (66 cm)	0.34 (0.21)	0.13 (0.10)	0.09 (0.11)	<0.01
	0.00, 0.90	0.00, 0.30	−0.10, 0.30	
LogMAR UIVA (80 cm)	0.68 (0.34)	0.09 (0.10)	0.08 (0.11)	<0.01
	0.10, 1.30	−0.10, 0.40	−0.10, 0.40	
LogMAR CIVA (80 cm)	0.13 (0.20)	0.08 (0.10)	0.07 (0.11)	0.23
	−0.10, 0.80	−0.10, 0.40	−0.10, 0.40	
Dcyl (D)	2.24 (1.16)	2.24 (1.10)	2.28 (1.24)	0.96
	1.23, 6.26	1.06, 5.70	1.10, 6.56	
Q (mm)	−0.13 (0.24)	−0.13 (0.24)	−0.15 (0.17)	0.15
	−0.80, 0.45	−0.55, 0.55	−0.48, 0.25	
KM	43.39 (1.68)	43.41 (1.60)	43.44 (1.71)	0.62
	40.78, 46.92	40.90, 46.92	40.80, 47.02	

CDVA corrected distance visual acuity, *CIVA* corrected intermediate visual acuity, *cm* centimeters, *CNVA* corrected near visual acuity, *DCIVA* distance-corrected intermediate visual acuity, *DCNVA* distance-corrected near visual acuity, *Dcyl* corneal astigmatism, *KM* mean keratometry, *mm* millimeters, *Q* corneal asphericity, *UDVA* uncorrected distance visual acuity, *UIVA* uncorrected intermediate visual acuity, *UNVA* uncorrected near visual acuity
P values are for comparisons between preoperative and postoperative follow-up values

and ± 0.50 D, respectively. Table 14.1 summarizes the preoperative and postoperative corneal data of patients included in this study. No statistically significant changes after surgery were observed in any corneal parameter (keratometric readings, asphericity, or magnitude of corneal astigmatism) ($p > 0.15$). Significant improvement in distance, intermediate, and near visual acuity was obtained. These outcomes in distance and near vision were consistent with previous studies with multifocal toric IOLs [1–7, 11–16]. The restoration of intermediate vision shows the

efficacy of this new technology to provide total visual rehabilitation after cataract surgery. Visual outcomes obtained with this model of IOL for all distances are similar to those achieved with this same model without toricity [4–7]. Regarding refractive outcomes, good refractive predictability was obtained for the postoperative sphere and cylinder according to previous studies with multifocal toric IOLs [4–7].

14.5 Defocus Curve

Figure 14.2 displays the mean binocular defocus curve. As shown, functional levels of visual acuity were obtained, with the maximum value when no defocus was presented. Visual acuities better than 0.2 logMAR were observed for defocus levels between +1.00 and − 3.00 D (Fig. 14.2). The defocus curve shows optimal visual acuity for defocus levels that correspond to distance, intermediate, and near vision. This defocus curve profile was consistent with previous reports that analyzed this model of trifocal IOL without toricity [1, 2]. This finding demonstrates that the toric trifocal IOL is as effective as the trifocal model without toricity in visual function rehabilitation. The maximum visual acuity is achieved at distance, with a slight drop in visual acuity for defocus levels corresponding to intermediate vision but within a functional level, and a slight visual recovery afterward for defocus levels corresponding to near vision. Visual acuity of 0.2 logMAR or better was observed between the defocus levels of +1.00 and − 3.00 D, as in previous reports with this model of trifocal IOL without toricity [1, 2].

14.6 Contrast Sensitivity

Figure 14.3 shows the mean contrast sensitivity function obtained in the group of eyes evaluated in the current study under photopic and mesopic conditions at 3 months after surgery. As shown, for photopic conditions the contrast sensitivity outcomes obtained were within the normal values for the age sample except for the spatial frequency of 18.0 cycles per degree (cpd). In mesopic conditions, the contrast sensitivity function data were near the normal values for all

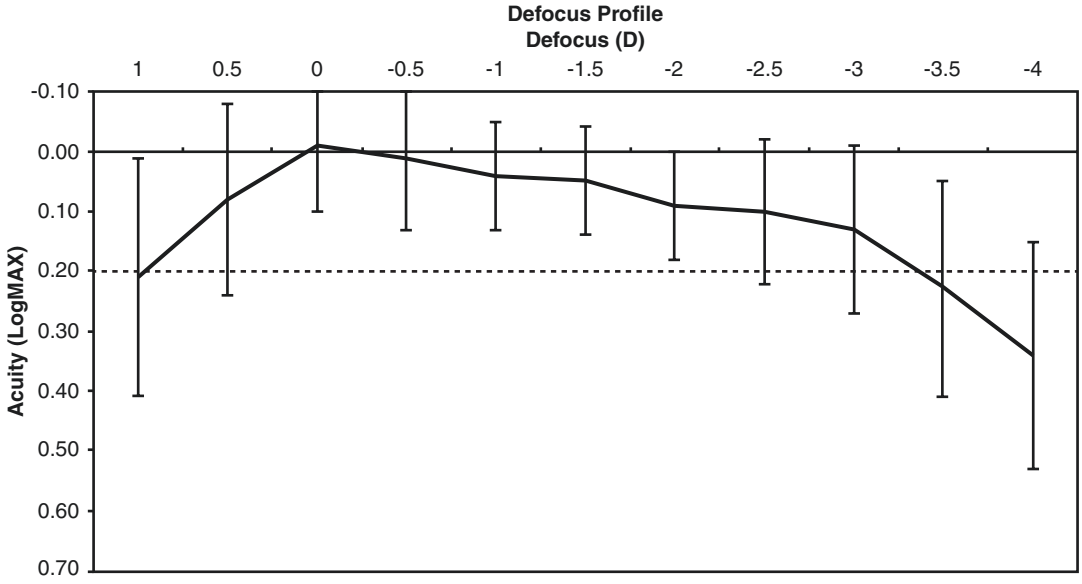

Fig. 14.2 Mean binocular defocus curve at 3 months postoperatively

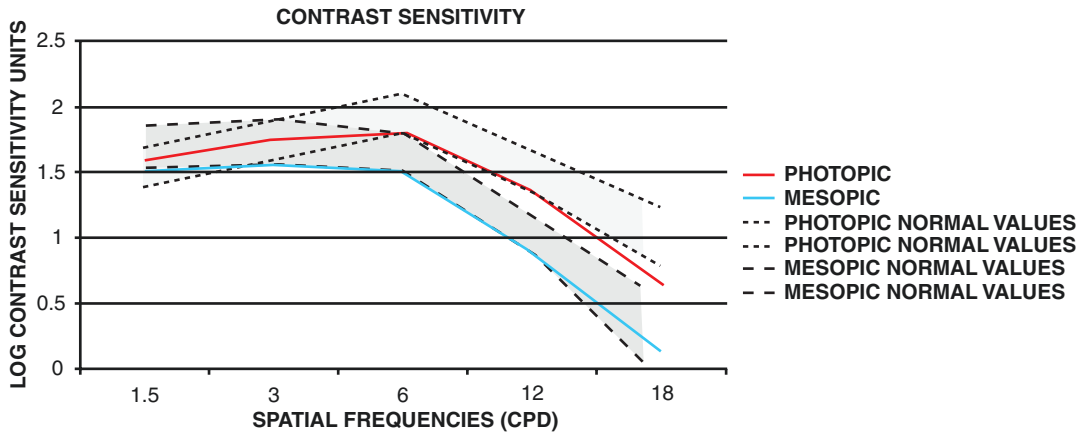

Fig. 14.3 Mean contrast sensitivity function under mesopic (green line) and photopic (red line) conditions at 3 months postoperatively

spatial frequencies except for 18.0 cpd, which was within the normal range. Contrast sensitivity obtained with this new model trifocal toric IOL were within or near the normal limits for the age sample analyzed. These outcomes were consistent with previous studies with other multifocal toric or trifocal IOLs [1–7].

14.7 Aberrometry

Tables 14.2, 14.3, and 14.4 summarize the preoperative and postoperative ocular, corneal, and internal aberrometric data for the current study, respectively. As shown, a statistically significant change with surgery was observed only in ocular tetrafoil Z4, 4 aberration ($p \leq 0.01$). Regarding the analysis of the aberrometric outcomes, a significant negative trend of only the ocular tetrafoil Z4,4 aberration was detected with the surgery. No significant changes were found in our series in regard to corneal aberrations, confirming the stability of corneal optics after surgery with the use of a microincision technique. Likewise, no significant changes were detected in internal or ocular aberrations. These findings demonstrate the low incidence of aberrations with the implantation of this model of trifocal toric IOL after cataract surgery.

14.8 Rotational Stability

IOL rotation is the main reason for ineffective astigmatism correction [17]. A previous report stated that 11.5 degrees of IOL rotation would lead to residual astigmatism of 40% of the attempted astigmatism correction, and that 3 degrees of IOL rotation would lead to a residual astigmatism of 10% of the desired astigmatism correction. The rotation of the IOL evaluated with the Refractive Power/Corneal Analyzer was 0 degrees in 40% (12 eyes), between 1 and 3 degrees in 53% (16 eyes), and between 4 and 5 degrees in 7.0% (2 eyes). Figure 14.4 shows a picture taken of an eye after trifocal toric IOL implanted analyzed by Refractive Power/Corneal Analyzer (Toric Summary Program) at 3 months after surgery. In this case report, 100% of the eyes had an IOL rotation of 5 degrees or less, and 73% of eyes had an IOL rotation of 3 degrees or less. These outcomes indicate an effective astigmatism correction with this model of trifocal toric IOL.

14.9 Patient Satisfaction

Tables 14.5 and 14.6 show the mean scores obtained for questions evaluating the difficulty in performing vision-related activities in the

Table 14.2 Preoperative and postoperative ocular aberrometric data for patients included in this study (5 mm pupil)

Mean (SD) range				
	Preoperative	1 Month	3 Months	*P* value, preoperative −3 Months
Tilt Z1, −1	−0.16 (0.51)	−0.21 (0.59)	−0.20 (0.51)	0.81
	−1.22, 0.95	−1.74, 0.45	−1.68, 0.54	
Tilt Z1, 1	−0.07 (0.27)	−0.05 (0.32)	−0.08 (0.24)	0.41
	−0.56, 0.48	−0.81, 1.12	−0.66, 0.61	
Trefoil Z3, −3	−0.24 (0.44)	−0.21 (0.31)	−0.25 (0.35)	0.35
	−1.64, 0.28	−1.29, 0.23	−1.62, 0.07	
Coma Z3, −1	−0.07 (0.22)	−0.08 (0.22)	−0.07 (0.20)	0.48
	−0.60, 0.31	−0.71, 0.17	−0.60, 0.20	
Coma Z3, 1	−0.01 (0.09)	−0.02 (0.12)	−0.03 (0.09)	0.13
	−0.17, 0.19	−0.30, 0.39	−0.26, 0.22	
Trefoil Z3, 3	0.03 (0.30)	0.05 (0.25)	0.05 (0.22)	0.35
	−0.52, 1.29	−0.31, 1.07	−0.64, 0.79	
Tetrafoil Z4, −4	0.00 (0.09)	0.00 (0.06)	0.00 (0.05)	0.47
	−0.21, 0.32	−0.12, 0.11	−0.12, 0.09	
SA Z4, 0	0.05 (0.08)	0.04 (0.06)	0.04 (0.06)	0.67
	−0.22, 0.21	−0.17, 0.14	−0.14, 0.16	
Tetrafoil Z4, 4	0.02 (0.08)	−0.02 (0.04)	−0.02 (0.04)	<0.01
	−0.13, 0.29	−0.13, 0.04	−0.12, 0.04	

P values are for comparison between preoperative and last postoperative visits

Table 14.3 Preoperative and postoperative corneal aberrometric data for patients included in this study (5 mm pupil)

Mean (SD) range				
	Preoperative	1 Month	3 Months	*P* value, preoperative to 3 Months
Tilt Z1, −1	−0.27 (0.96)	−0.30 (0.98)	−0.33 (0.91)	0.32
	−3.23, 1.18	−3.41, 0.62	−3.45, 0.64	
Tilt Z1, 1	−0.06 (0.62)	−0.09 (0.66)	−0.10 (0.55)	0.33
	−1.40, 1.87	−2.02, 2.06	−1.87, 1.56	
Trefoil Z3, −3	−0.13 (0.33)	−0.09 (0.25)	−0.11 (0.29)	0.88
	−1.20, 0.33	−0.99, 0.20	−1.25, 0.19	
Coma Z3, −1	−0.11 (0.34)	−0.13 (0.37)	−0.13 (0.37)	0.32
	−1.07, 0.27	−1.18, 0.28	−1.22, 0.31	
Coma Z3, 1	0.01 (0.21)	−0.02 (0.24)	−0.02 (0.20)	0.12
	−0.45, 0.77	−0.75, 0.83	−0.68, 0.62	
Trefoil Z3, 3	0.05 (0.23)	0.05 (0.22)	0.03 (0.21)	0.54
	−0.31, 1.08	−0.23, 1.09	−0.49, 0.79	
Tetrafoil Z4, −4	−0.02 (0.10)	−0.01 (0.08)	−0.01 (0.07)	0.33
	−0.33, 0.14	−0.31, 0.17	−0.23, 0.24	
SA Z4, 0	0.13 (0.10)	0.16 (0.17)	0.13 (0.08)	0.49
	−0.22, 0.32	−0.19, 0.83	−0.16, 0.29	
Tetrafoil Z4, 4	−0.01 (0.09)	−0.04 (0.08)	−0.03 (0.05)	0.52
	−0.28, 0.32	−0.38, 0.09	−0.169, 0.07	

P values are for comparison between preoperative and last postoperative visits

patient satisfaction questionnaire and VF 14 questionnaire. In our study, the VF-14 questionnaire yielded a mean value of 92.50 (range 67.9 to 100). Desai et al. indicated satisfactory success when, after cataract surgery with a standard IOL implanted, 85% of patients obtained 90 points or more on the VF-14 questionnaire [18]. In our study, nearly 85% of patients had a score

Table 14.4 Preoperative and postoperative internal aberrometric data for patients included in this study (5 mm pupil)

Mean (SD) range				
	Preoperative	1 Month	3 Months	*P* value, preoperative to −3 Months
Tilt Z1, −1	0.11 (0.60)	0.06 (0.55)	0.13 (0.50)	0.47
	−0.46, 2.09	−1.53, 1.60	−0.48, 1.77	
Tilt Z1, 1	−0.01 (0.54)	−0.07 (0.58)	0.02 (0.48)	0.88
	−1.42, 1.24	−2.11, 1.21	−0.95, 1.26	
Trefoil Z3, −3	−0.11 (0.19)	−0.11 (0.13)	−0.14 (0.11)	0.39
	−0.56, 0.44	−0.47, 0.18	−0.37, 0.06	
Coma Z3, −1	0.04 (0.19)	0.05 (0.17)	0.07 (0.18)	0.19
	−0.16, 0.65	−0.18, 0.52	−0.15, 0.66	
Coma Z3, 1	−0.03 (0.17)	−0.03 (0.20)	−0.01 (0.17)	0.49
	−0.58, 0.31	−0.65, 0.46	−0.40, 0.42	
Trefoil Z3, 3	−0.02 (0.15)	0.00 (0.09)	0.02 (0.10)	0.32
	−0.50, 0.32	−0.24, 0.18	−0.16, 0.37	
Tetrafoil Z4, −4	0.02 (0.10)	0.01 (0.06)	0.00 (0.05)	0.42
	−0.10, 0.46	−0.12, 0.19	−0.14, 0.13	
SA Z4, 0	−0.08 (0.11)	−0.09 (0.07)	−0.09 (0.06)	0.98
	−0.39, 0.25	−0.39, 0.02	−0.25, 0.03	
Tetrafoil Z4, 4	0.03 (0.09)	0.01 (0.08)	0.01 (0.06)	0.09
	−0.13, 0.35	−0.15, 0.36	−0.09, 0.20	

P values are for comparisons between preoperative and last postoperative visits

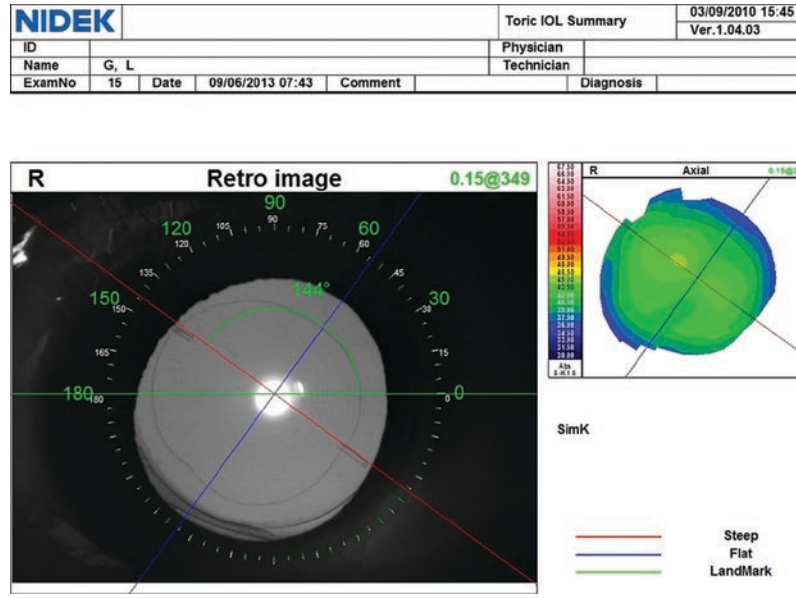

Fig. 14.4 Image of an eye after trifocal toric IOL implantation analyzed with OPD scan II

higher than 90.00. This issue demonstrates good patient satisfaction after implantation of a toric trifocal IOL. In the appendix of optional additional questions, patients reported little difficulty in performing all tasks, with the most difficult task reported by patients being driving at night. Table 14.7 summarizes the correlation between QOL items and visual parameters. As shown, low to moderate levels of difficulty in performing different types of vision-related tasks were found. Correlations between QOL and clinical data were investigated. As expected, significant

Table 14.5 Summary of mean postoperative scores obtained for questions on vision-related activities in the patient satisfaction questionnaire

Activity	Mean (SD) range
Difficulty in seeing and enjoying programs on TV	1.38 (0.50)
	1.00, 2.00
Difficulty in driving during the daytime in familiar places	1.19 (0.40)
	1.00, 2.00
Difficulty in driving at night	2.25 (1.12)
	1.00, 5.00
Difficulty in going out to see movies, theater, plays, or sports events	1.38 (0.81)
	1.00, 4.00
Difficulty in entertaining friends and family in your home	1.19 (0.40)
	1.00, 2.00
Difficulty in doing work or hobbies that require close-up vision, such as cooking or sewing	1.25 (0.45)
	1.00, 2.00
Difficulty in working with PC	1.63 (0.72)
	1.00, 3.00
Difficulty in reading ordinary print in newspapers	1.44 (0.76)
	1.00, 3.00
Difficulty in shaving, styling hair, or putting on makeup	1.19 (0.40)
	1.00, 2.00

PC personal computer
Scale: 1 = excellent; 2 = very good; 3 = good; 4 = not completely satisfied; 5 = dissatisfied; 6 = very dissatisfied

Table 14.6 Mean values on postoperative National Eye Institute Visual Functioning Questionnaire–14

Activity	Mean (SD) Range
1. Reading small print, such as medicine bottle labels, a telephone book, or food labels	3.25 (0.93)
	1.00, 4.00
2. Reading a newspaper or book	3.63 (0.81)
	1.00, 4.00
3. Reading a large-print book or large-print newspaper or numbers on a telephone	3.94 (0.25)
	3.00, 4.00
4. Recognizing people when they are close to you	3.81 (0.54)
	2.00, 4.00
5. Seeing steps, stairs, or curbs	3.88 (0.34)
	3.00, 4.00
6. Reading traffic signs, street signs, or store signs	3.56 (0.63)
	2.00, 4.00
7. Doing fine handwork like sewing, knitting, crocheting, carpentry	3.69 (0.60)
	2.00, 4.00
8. Writing checks or filling out forms	3.79 (0.43)
	3.00, 4.00
9. Playing games such as bingo, dominos, card games, or mahjong	3.88 (0.34)
	3.00, 4.00
10. Taking part in sports like bowling, handball, tennis, golf	3.94 (0.25)
	3.00, 4.00
11. Cooking	3.88 (0.34)
	3.00, 4.00
12. Watching television	3.75 (0.58)
	2.00, 4.00
13. Driving during the day	3.88 (0.50)
	2.00, 4.00
14. Driving at night	3.06 (0.85)
	1.00, 4.00

Scale is from 4 = no difficulty to 0 = unable to do

correlations between visual tasks with contrast sensitivity, optical aberrations, and glare intensity were found. These findings indicate that, when optical aberrations increase, patient satisfaction with performing everyday tasks decreases; when contrast sensitivity decreases, difficulty in reading traffic signs increases. These findings are consistent with previous studies that correlate visual and quality of life questionnaire responses [19]. The analysis with the halo and glare simulator revealed the presence of halos with a mean size of 44.87 ± 16.96 (range 19 to 75) and a mean intensity of 52.88 ± 10.66 (range 40 to 75). Halos were classified as type 1 in 31.25% (5 eyes), type 2 in 56.25% (9 eyes), and type 3 in 12.5% of patients (Fig. 14.5). The mean glare size and intensity were 26.69 ± 13.36 (range 0 to 49) and 46.50 ± 16.63 (range 14 to 68), respectively.

Regarding photic phenomena, perception, glare, and halos were perceived in the initial postoperative period by a significant portion of patients, but most of these phenomena were reported not to be disturbing.

Table 14.7 Correlations between quality-of-life items and visual parameters 3 months after implantation of trifocal toric IOL

	Correlation 1	Correlation 2	Correlation 3	Correlation 4
Difficulty in working with PC (1 = no difficulty to 5 = stopped doing this)	Ocular coma Z3, −1	Glare intensity		
	$r = 0.370$, $p = 0.04$	$r = 0.374$, $p = 0.04$		
Difficulty in seeing and enjoying programs on TV (1 = no difficulty to 5 = stopped doing this)	Ocular tetrafoil Z4, 4	Glare intensity		
	$r = 0.417$, $p = 0.02$	$r = 0.481$, $p < 0.01$		
Difficulty in going out to see movies, theater, plays, or sports events (1 = no difficulty to 5 = stopped doing this)	Ocular trefoil Z3, −3	Glare intensity		
	$r = 0.420$, $p = 0.02$	$r = 0.475$, $p < 0.01$		
Difficulty in entertaining friends and family in your home (1 = no difficulty to 5 = stopped doing this)	Ocular SA	Corneal tetrafoil Z4, 4	Glare intensity	
	$r = 0.414$, $p = 0.02$	$r = 0.414$, $p = 0.02$	$r = 0.512$, $p < 0.01$	
Difficulty in driving during the daytime in familiar places (1 = no difficulty to 5 = stopped doing this)	Ocular SA	Glare intensity		
	$r = 0.395$, $p = 0.03$	$r = 0.599$, $p < 0.01$		
Difficulty in driving at night (1 = no difficulty to 5 = stopped doing this	Ocular trefoil Z3, −3	Corneal trefoil Z3, −3	Glare intensity	
	$r = 0.384$, $p = 0.04$	$r = 0.407$, $p = 0.03$	$r = 0.391$, $p = 0.03$	
1. Reading small print size, such as medicine labels, a telephone book, or food labels	Glare intensity			
	$r = -0.628$, $p < 0.01$			
2. Reading a newspaper or book	Ocular SA			
	$r = -0.527$, $p < 0.01$			
3. Reading a large-print book or large-print newspaper or numbers on a telephone	Ocular SA	Internal coma Z3, −1	Glare intensity	
	$r = -0.401$, $p = 0.03$	$r = -0.417$, $p = 0.02$	$r = -0.433$, $p = 0.02$	
5. Seeing steps, stairs, or curbs	Corneal SA			
	$r = -0.408$, $p = 0.03$			
6. Reading traffic signs, street signs, or store signs	Photopic CSF 12 cpd	Photopic CSF 18 cpd	Corneal tetrafoil Z4,4	
	$r = 0.381$, $p = 0.04$	$r = 0.423$, $p = 0.02$	$r = -0.389$, $p = 0.03$	
8. Writing checks or filling out forms	Ocular SA	Internal SA Z4,0		
	$r = -0.424$, $p = 0.02$	$r = -0.395$, $p = 0.03$		
9. Playing games such as bingo, dominos, card games, or mahjong	Scotopic CSF 3 cpd	Scotopic CSF 18 cpd	Glare intensity	

Table 14.7 (continued)

	Correlation 1	Correlation 2	Correlation 3	Correlation 4
	$r = -0.600$, $p = 0.01$	$r = -0.561$, $p = 0.02$	$r = -0.432$, $p = 0.02$	
10. Taking part in sports such as bowling, handball, tennis, golf	Internal trefoil Z3, −3			
	$r = -0.371$, $p = 0.04$			
11. Cooking	Ocular SA	Glare intensity		
	$r = -0.464$, $p = 0.01$	$r = -0.591$, $p < 0.01$		
12. Watching television	Glare intensity			
	$r = -0.403$, $p = 0.03$			
13. Driving during the day	Ocular trefoil Z3, −3			
	$r = -0.386$, $p = 0.04$			
14. Driving at night	Ocular trefoil Z3, −3	Ocular tetrafoil Z4, 4	Internal trefoil Z3, −3	Glare intensity
	$r = -0.540$, $p < 0.01$	$r = -0.470$, $p < 0.01$	$r = -0.492$, $p < 0.01$	$r = -0.382$, $p = 0.01$

PC personal computer, *TV* television

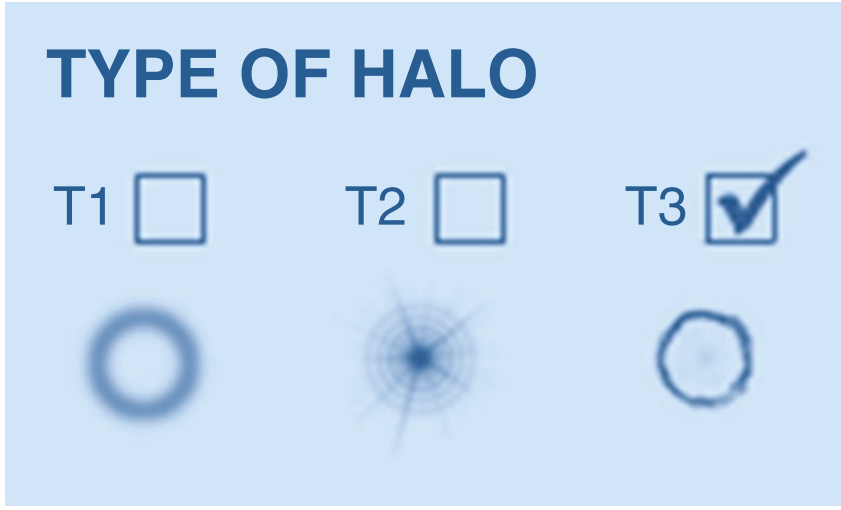

Fig. 14.5 Halo and glare simulator classification

14.10 Vector Analysis of Astigmatic Changes

With regard to vector analysis of the astigmatism changes, we used the Alpins method to evaluate the magnitude and axis refractive astigmatism variation with the surgery. The mean magnitude of the TIA was 1.87 ± 1.76 D (range 1.25 to 6.94 D), and the mean magnitude of SIA was 1.92 ± 1.55 D (range 0.22 to 6.33 D). A statistically significant difference ($p = 0.04$) was found between the SIA and TIA vectors,

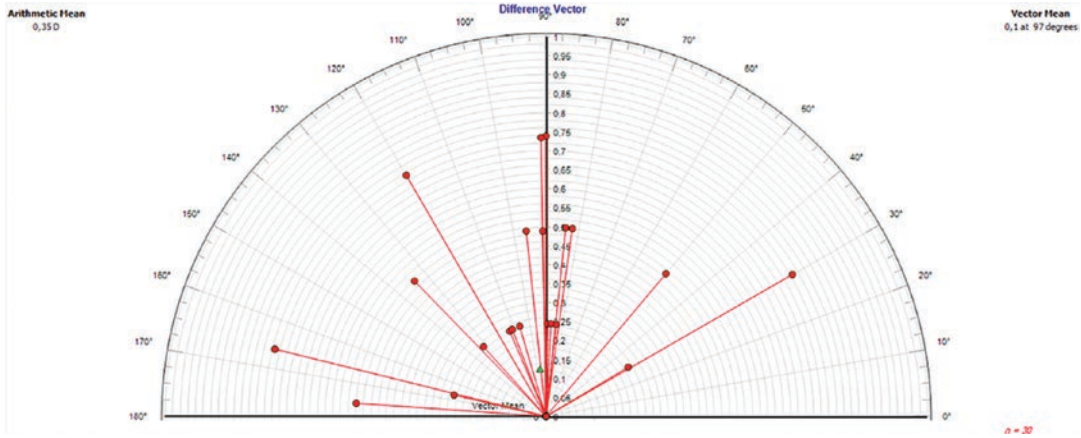

Fig. 14.6 Vectorial display of the difference vector during postoperative follow-up. It represents the astigmatism that should be induced additionally to achieve the intended target in each case

with slightly high values for the SIA vector, the mean magnitude of error was positive (overcorrection) and close to 0 (0.06 ± 0.30 D, range 0.70 to 0.50 D). Likewise, the mean difference vector was also very close to 0 (0.35 ± 0.25 D, range 0.00 to 0.77 D) (Fig. 14.6). Therefore, there was a minimal trend toward overcorrection of the refractive astigmatism after implantation of the toric trifocal IOL evaluated, which was without clinical relevance. The mean magnitude of the angle of error (5.80 ± 8.47 degrees) was positive, and therefore the achieved correction was slightly counterclockwise to the intended axis on average. The presence of a small rotation of the IOL inside the capsular bag in some cases might be the main factor explaining the low tendency toward astigmatic overcorrection observed in our series. The torque vector must be seen in relation to misalignments of the astigmatism correction. The torque vector represents the amount of astigmatic change induced by the SIA that was ineffective in reducing astigmatism at the intended meridian but caused rotation and a small increase in the existing astigmatism [10, 16, 20]. If the treatment is 100% effective, this vector would be 0. In this study, a torque vector of 0.27 D was obtained. This value is close to 0 and indicates a low rate of astigmatic change induced by the SIA.

14.11 Conclusion

Trifocal toric AT LISA tri toric 939 M/MP provides good visual rehabilitation for all-distance vision after cataract surgery, with effective correction of significant corneal astigmatism. Contrast sensitivity outcomes and the low incidence of aberration induction account for the patient satisfaction with this innovative IOL technology.

Compliance with Ethical Requirements Peter Mojzis declares he has no conflict of interest. All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000. Informed consent was obtained from all patients for being included in the study. No animal studies were carried out by the authors for this article.

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