

Original Article

Visual outcomes and patient satisfaction after bilateral implantation of a new trifocal diffractive intraocular lens



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Abstract

Purpose: To assess the visual outcomes, patient satisfaction and spectacle independence following implantation of new diffractive trifocal intraocular lenses.

Setting: 2 centers (university-based practice and a private practice set up).

Patients and methods: Prospective nonrandomized study in which 74 AT LISA TRI 839MP and 8 AT LISA TORIC TRI 939MP IOLs implanted bilaterally in 41 patients following either cataract extraction or refractive lensectomy, follow-up was done at 1st, 2nd and 3rd months to assess the visual and refractive outcomes. Also, a questionnaire was used to assess patient satisfaction, spectacle independence and photic phenomena after the surgery.

Results: Mean uncorrected monocular distance decimal visual acuity (UDVA) was preoperatively 0.35. The averages of uncorrected monocular distance/intermediate/near (UDVA/UIVA/UNVA) postoperatively were 0.90/0.87/0.91 at 3 months. 87.5% patients had SE within ± 0.50 by the 3rd month. Nearly all the patients were satisfied with the surgical outcome and the reported photic phenomena by some patients were non-disturbing with noticeable high level of patient's satisfaction by the third month.

Conclusion: Diffractive trifocal IOLs can provide with satisfactory visual and refractive results along with positive impact on the performance of vision-related daily activities with minimal level of non-disturbing photic phenomena to patients.

Keywords: Trifocal IOLS, Visual outcomes, AT LISA, Diffractive IOLS, Intermediate vision

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Introduction

The current state of art for the correction of aphakia and presbyopia after cataract extraction and refractive lensectomy is the implantation of multifocal-Intraocular lenses (IOLs).¹ In the past, the traditional design of multifocal IOLs was bifocal which allowed the patient to gain a good postoperative near and distance visual function without full correc-

tion of intermediate vision which is extremely important for desktop and computer work.^{2,3} The recent advancement of IOL multifocality technologies resulted in trifocal diffractive IOLs. This new IOLs aided the concept of spectacle independence of full range of vision distances; far, intermediate and near after cataract extraction and refractive lensectomy.^{1,4} As stated by the manufacturer, the optical outcome of this trifocal IOL is achieved by means of an asymmetric distribution of

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light, with 30% of near vision, 20% of intermediate vision and 50% of distance vision.

In this study, the particular trifocal IOLs were assessed by AT LISA tri 839MP and AT LISA toric 939 MP (Carl Zeiss meditec, Jena, Germany), which combine a central 4.3 mm trifocal area with a bifocal diffractive surface between 4.3 mm and 6 mm of diameter. Previous studies confirmed an excellent uncorrected distance, intermediate and near visual outcomes with minimal level of photic phenomena by using this trifocal IOL.^{5,6} The results of spectacle independence were high, reaching approximately 90% in most of the studies. Law et al., reported that a limited percentage of patients had some difficulties during performing near and intermediate visual tasks without glasses; such as reading the newspaper or working with the computer. High level of satisfaction was obtained in mostly all of the studies. 88% of patients would choose the same type of IOL again, and 86% of patients would recommend the surgery with the same design of IOL to the others.⁷

The aim of this study is to assess the performance of these IOLs in terms of visual acuity at different distances, refractive predictability and also to evaluate patient satisfaction, spectacle independence and photic phenomena after bilateral implantation of this type of trifocal diffractive IOLs by following either cataract extraction or refractive lensectomy.

Methods

Population of the study

In this prospective non-randomized study, 82 eyes of 41 patients underwent bilateral cataract extraction (N = 32 eyes) and refractive lensectomy (N = 50 eyes) followed by implantation of the diffractive trifocal AT LISA TRI 839MP IOLs (Carl Zeiss Meditec, Jena, Germany) except 8 eyes with astigmatism of >1.25 D for whom AT LISA TRI TORIC 939MP IOLs were implanted. All patients were adequately consulted preoperatively about this type of IOLs and also they were verbally consented. The study was conducted from December 2016 to June 2017. The study is adherent to the tenets of the Declaration of Helsinki and it was approved by the local committee of research ethics.

Inclusion and exclusion criteria

The included patients had cataract or presbyopia/pre-presbyopia suitable for refractive lens exchange and were

seeking spectacle independence. The excluded patients had the defects such as history of glaucoma, retinal detachment, corneal disease, irregular corneal astigmatism, abnormal iris, macular degeneration, advanced retinopathy, neuro ophthalmic disease, the history of ocular inflammation or previous ocular surgery. Eight eyes with regular astigmatism of >1.25 D were included and underwent a separate analysis of refractive outcome as they have extreme cylinder readings.

Preoperative and postoperative assessments

Prior to the surgical procedure, a complete ocular examination was done, including slit lamp examination, Goldman applanation tonometry, uncorrected distance visual acuity (UDVA), corrected distance visual acuity (CDVA) and corrected near visual acuity (CNVA), manifest refraction with calculation of the spherical equivalent (SE), keratometry and biometry (IOL Master v.4.3, Carl Zeiss Meditec, Jena, Germany), corneal tomography (Pentacam HD, oculus, Wetzlar, Germany) and funduscopy. Postoperative evaluation was performed on 1st day, 1st month and 3rd month after the second eye surgery. The postoperative protocol was identical to preoperative one with the additional evaluation of monocular and binocular uncorrected (UIVA) intermediate visual acuity (66 cm)^{8,9} and monocular and binocular uncorrected (UNVA) near visual acuity (40 cm) under the photic condition. Careful assessment of the status of IOL was done to look for any posterior capsular opacity (PCO) or malposition. In addition, all patients completed a validated questionnaire called visual function index (VF-14) at postoperative visits on 1st and 3rd months for comparison (Table 1). The test measures the functional capacity related to vision based on 14 vision-dependent activities performed in everyday life at different distances and lightening conditions. A validated Arabic translation of the English version was adapted from another study which was done by 2 bilingual authors independently (Table 1).^{10,11}

The participants of the study were interviewed on their satisfaction level for 14 different near, intermediate and far visual activities. "Near" activities included: reading small prints, reading newspaper or a book, writing checks or filling out forms, reading a largeprint book or numbers on a telephone. "Intermediate" activities covered: seeing steps, stairs or curbs, fine household work like sewing and carpentry, playing games like dominos or card games, and finally cooking. "Distance" visual activities included: recognizing

Table 1. English version and Arabic Translation of the VF-14 Questionnaire:

1	Reading small prints such as labels on medicine and telephone directory	قراءة النصوص الصغيرة مثل نشرات الأدوية ودليل التليفون
2	Reading newspapers or books	قراءة الكتب أو الجرائد
3	Reading large print books	قراءة النصوص الكبيرة في الكتب
4	Recognizing people when they are close to you	التعرف على الأشخاص عند اقترابهم منك
5	Seeing steps and stairs	رؤية درجات السلم، عتبات البيوت
6	Reading traffic signs, street names, and store signs	رؤية علامات المرور وأسماء الشوارع والمحلات
7	Doing fine handwork like sewing and carpentry	القيام بأعمال يدوية دقيقة مثل الخياطة والتطريز وأعمال النجارة
8	Writing checks or filling out forms	كتابة الشيكات أو ملء الاستمارات أو كتابة الخطابات
9	Playing card, games, dominos	ممارسة ألعاب الورق و الدومينو
10	Taking part in sports like handball	ممارسة الرياضة
11	Cooking	الطهو
12	Watching TV	مشاهدة التلفزيون
13	Driving during day	القيادة أثناء النهار
14	Driving at night	القيادة في الليل

people when they are close to you, reading traffic street signs, taking part in sports, watching TV, daytime driving, and night time driving. Patients were asked if they had difficulty in doing each of the activities. If so patients were responding by "yes" to rate the amount of difficulty as 4 = No Difficulty, 3 = A Little, 2 = Moderate Amount, 1 = Great Deal of Difficulty, and 0 = Unable to do the Activity at All because of His Vision. A score was obtained by averaging the responses of all activities answered by every patient, then multiplied by 25 to get a final score. Non-applicable items for some patients are not considered and the score was calculated from the answered items only; for example, if a patient does not drive, items 13 and 14 will not be applicable for him and the score will be considered for the remaining 12 items. The VF-14 score can range from 0 (unable to perform all applicable activities) to 100 (able to perform all applicable activities without difficulties). The validity and internal consistency of the VF-14 have been documented.^{11,12} A supplementary self-developed questionnaire was used to address any difficulty while performing few activities at variable distances (scale: 1 = no difficulty; 2 = moderately difficult; 3 = difficult; and 4 = unable to perform) (activities such as: reading the newspaper, reading a book, watching TV, driving a car during the day, driving a car at night and doing computer work), due to the lack in VF-14 to include difficulty in computer use as it is an important variable now a days that assess the intermediate vision (60–90 cm distance).⁶ Additionally, patients were asked about their level of satisfaction after the surgery (very dissatisfied, fairly dissatisfied, fairly satisfied, very satisfied, cannot decide) and percentage of each answer was calculated. Patients were also asked about the frequency of photic phenomena (such as glare and halos) whether they are disturbing or not. Postoperative spectacle independence was assessed by asking the patient if they still use glasses for near, intermediate and far activities. Finally, patients were asked; would they choose the same IOL model again? and whether they would recommend the surgery with same IOL model to others or not?. Intraocular lens power and predicted postoperative refractions were based on biometry data measured with the IOL Master device and calculated using the Haigis or SRK/T formula. The IOL power was selected to provide a postoperative refraction closest to emmetropia.

Surgical technique

All surgeries were performed by one experienced surgeon (KA) using a standard technique of sutureless phacoemulsification. In all cases, either topical or peribulbar anesthesia was administered and pharmacologic mydriasis was induced using a combination of tropicamide and phenylephrine (10.0%). A mean clear corneal microincision of 2.2 mm was made with a microkeratome. A paracentesis was made 60 degree to 80 degree, clockwise from the main incision, and the anterior chamber was filled with an ophthalmic viscosurgical device (OVD) after phacoemulsification/lensectomy and removal of the cataract/clear lens. The IOL was subsequently implanted through the main incision using the BLUE-MIXS 180 injector (Carl Zeiss meditec, Jena, Germany) and then the OVD was removed. Postoperative pharmacologic treatment is performed with the combination of antibiotic and steroidal anti-inflammatory drops.

Intraocular lens

Both AT LISA TRI 839MP and AT LISA TRI TORIC 939MP (for significant regular astigmatism) IOLs are designed for aphakia correction after crystalline lens removal in eyes with senile cataract and any other forms of cataract. They are also indicated for presbyopia correction for patients with and without cataract (presbyopic lens exchange or refractive lens exchange). They are designed to be implanted into an intact capsular bag as a microincision IOL, and no enlargement of the incision (1.8 mm) is needed with the Bluemixs injector. The IOL material is a biocompatible hydrophilic copolymer with UV filter. The IOL material has 25% of water content at 35C. The IOLs are trifocal within a lens diameter of 4.3 mm and bifocal between 4.3 mm and 6 mm diameter. The add powers within the 4.3 mm diameter are 1.66 diopters to intermediate and 3.33 diopters to near distance. The add power between the 4.3 mm and 6 mm diameter is 3.75 diopters.⁴ (Fig. 1).

Statistical analysis

All categorical data were represented by frequency with percentage. Continuous data were presented by mean with standard deviation and range. Significant difference among pre, 1st month and 3rd month were tested by using the repeated measure ANOVA for normal data, and Friedman test was used for abnormal data. Paired t-test was used to test the significant difference between pre and 1st month Visual Function Index. All the analyses were done by using SPSS 21.0 version. If the value of P was less than 0.05 then they were considered as significant.

Results

The study has been conducted the total of 82 eyes of 41 patients (20 were males and 21 were females), and most of the patients approximately, 34 were from the age group of 41 to 60, 5 from 20 to 40 age group and 2 patients were aged 61 and above. The indication for IOL implantation was following either refractive lensectomy (N = 50 eyes) or bilateral cataract extraction (N = 32 eyes). Mean preoperative manifest sphere for cataract patients and cylinder were -1.04 D

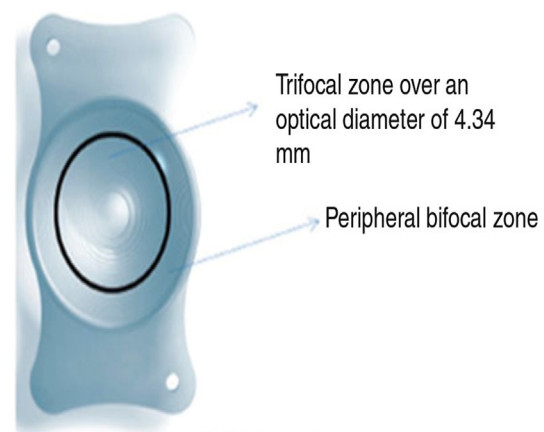


Fig. 1. Optics of AT LISATri consists of two parts, central 4.34 mm trifocal zone and peripheral bifocal.

(range, -10.75 to +3.50 D) and +0.04 D (range, -1.75 to +4.00 D) respectively. Mean preoperative spherical equivalent for cataract patient was -1.01 D (range, -11.38 to +4.25 D). Mean preoperative manifest sphere and cylinder for refractive lensectomy were +0.62 D (range, -15.9 to +6.75 D) and -0.22 D (range -1.50 to 2.25 D) respectively. Mean preoperative spherical equivalent for refractive lensectomy was +0.51 D (range, -15.75 to +6.50 D). In toric IOLs group the preoperative sphere, cylinder and SE were -6.9 D, -3.8 D and -8.87 D respectively. The mean preoperative CDVA was 0.74 and also the mean IOL power implanted was 21.3 D.

Visual acuity

Mean monocular UDVA increased significantly from 0.35 to 0.90 after 3 months (P value < 0.001) with 75% of eyes achieved ≥0.8. Mean monocular CDVA after 3 months is 0.95. Binocular UDVA is 0.96 in the 3rd month postoperatively (range, 0.67-1.00) described at Table 2 and Fig. 2.

Mean monocular UIVA is 0.87 after 3 months with 81.7% of eyes achieved ≥0.8 (Table 2) and (Fig. 2). Mean binocular UIVA is 0.88 after 3 months and Preoperative UIVA was not measured. Mean monocular uncorrected UNVA is 0.91 after 3 months with 90.4% of eyes achieved ≥0.8. Mean binocular UNVA is 0.92 after 3 months (Table 2) and (Fig. 2). Preoperative UNVA was not measured.

Predictability and refractive outcome

Regarding the spherical equivalent (SE), it was within ±0.50 in 87.5% of eyes at 3 months after the surgery with a mean 3rd month postoperative spherical equivalent for the cataract group of -0.04 D (range, -1.25 to +1.38 D) and with a mean 3rd month post-operative spherical equivalent for the refractive group was -0.14 D (range, -1.38 to +0.50 D). The differences in sphere, cylinder and SE were statistically significant preoperatively and postoperatively at 1st month and 3rd months (p value was < 0.001, 0.004 and 0.001 respectively) in the refractive group but statistically insignificant in the cataract group (Table 3). In patients, who has undergone the toric IOLs implantation, the postoperative SE at 3rd months was -0.37 D with and the cylinder was -0.8 D with significant p value of <0.005 and 0.018 respectively (Table 4).

Intraocular lens position and rate of PCO

No evidence of IOL decentration or PCO was noticed during the follow-up period.

Ability to perform daily activities, patient overall satisfaction and spectacle independence

Results of the VF-14 showed an incremental change in the overall mean from 50% in the first month postoperatively and

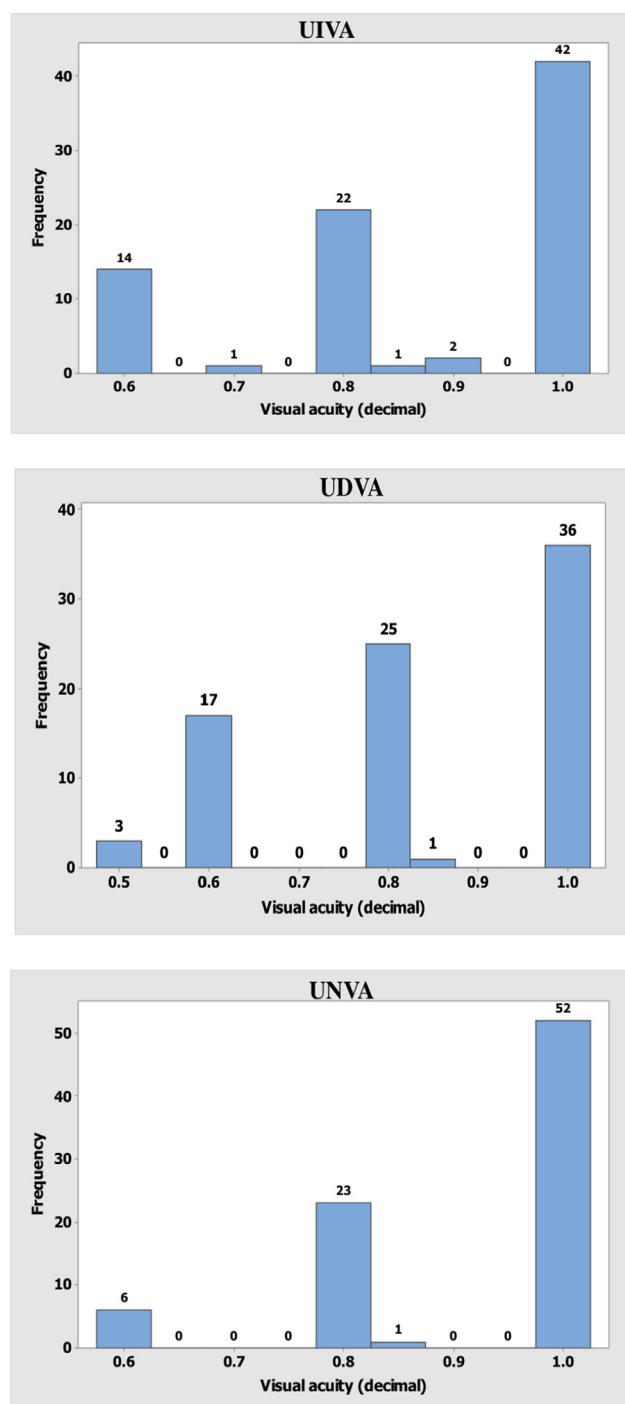


Fig. 2. Distribution of UIVA, UDVA and UNVA at the month of 3 postoperatively.

72% in the third month postoperatively (Fig. 3), for both cataract and refractive groups, with statically significant P value was <0.001. Most of the patients 90.24% were very satisfied with their vision in the third month postoperatively. On the

Table 2. Mean monocular visual acuity.

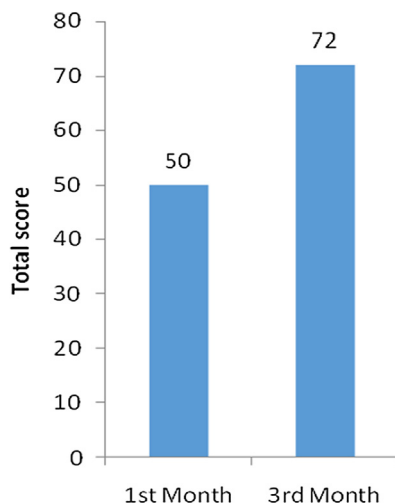
Time periods	UDVA	CDVA	CNVA	UIVA	UNVA
Preoperatively	0.35(0.2)	0.74(0.6)	0.78(0.5)	-	-
1st Month	0.89(0.2)	-	-	0.84(0.1)	0.88(0.5)
3rd Month	0.90(0.2)	0.95(0.1)	-	0.87(0.2)	0.91(0.1)
P value	<0.001**	-	-	0.123	0.184

Table 3. Describes refractive outcomes before and after implantation of AT LISA TRI 839MP IOLs.

	Cataract Mean (SD) Minimum–Maximum			Refractive Mean (SD) Minimum–Maximum		
	Sphere	Cylinder	SE	Sphere	Cylinder	SE
Pre-operative	–1.04 (3.6) –10.75 to 3.50	0.04(1.4) –1.75 to 4.00	–1.01(3.7) –11.38 to 4.25	0.62(4.7) –15.0 to 6.75	–0.22(1.2) –1.5 to 2.25	0.51(4.8) –15.75 to 6.50
1st month	0.10(0.4) –1.00 to 1.00	–0.29(0.6) –1.50 to 1.00	–0.04(0.5) –1.25 to 1.38	0.04(0.5) –1.0 to 1.50	–0.36(0.6) –3.5 to 0.75	–0.14(0.6) –2.50 to 1.50
3rd Month	–0.03(0.3) –1.25 to 0.5	–0.42(1.6) –8.50 to 0.75	–0.25(0.8) –4.25 to 0.38	–0.04(0.3) –1.0 to 1.0	–0.21(0.3) –1.0 to 0.5	–0.14(0.3) –1.38 to 0.50
P value	0.558	0.273	0.428	<0.001**	0.004*	<0.001**

Table 4. Refractive outcomes before and after implantation of AT LISA TRI TORIC 939MP IOLs.

	Sphere Mean (SD) Minimum–Maximum	Cylinder Mean (SD) Minimum–Maximum	SE Mean (SD) Minimum–Maximum
Pre	–6.9 (6.5) –17.0 to 1.00	–3.8 (0.8) –5.25 to –2.50	–8.8 (6.6) –19.6 to –0.25
1st month	0 (0.3) –0.50 to 0.50	–1.1 (0.6) –2.25 to –0.25	–0.53 to 0.27 –0.88 to –0.12
3rd month	0.03 (0.4) –0.75 to 0.75	–0.8 (0.6) –2.00 to –0.25	–0.37 (0.3) –0.88 to 0
P value	<0.001**	0.018*	0.005*

**Fig. 3.** Visual Function Index-14.

other hand, 9.7% documented that they are fairly satisfied with the visual results. High satisfaction rates in terms of visual function for near, intermediate and distant visions, while (Fig. 4) demonstrated the answers when the patients were questioned about performing daily activities. Almost all patients (94%) reported that there is no difficulty when reading a book, while 85% reported no difficulty when working on a computer and different rates of visual response was noted while driving a car at daylight compared during the drive at night, and driving at night being more bothersome for some patients. All of the participants (total of 41 patients) were willing to undergo the surgery again and would recommend the same IOL model to others. Moreover, 92% of the patients were spectacle independent for near, intermediate and far distances. Minority of the patients 4.8% and 2.4% were spectacle dependent for distant and intermediate vision respectively (Table 5).

Photic phenomena and other visual disturbance

Glare, halos, starburst, and blurring, all been reported with 21.9%, 65.8%, 2.4%, 4.8% respectively one-month of post operatively, the percentages decreased after the third month to 4.8% for glare, and notably haloes and blurred vision decreased to half with the percentage of 34.1% and 2.4% respectively, whereas starburst persisted as shown in (Table 5). Among those patients who reported photic phenomena by the 1st month (N = 39) only 2 patients found the disturbing of vision but by the 3rd month (N = 18) none of the patients reported as being disturbed by vision.

Discussion

Visual and refractive outcomes

New diffractive multifocal IOLs such as AT LISA tri 839MP and AT LISA toric 939MP (Carl Zeiss meditec, Jena, Germany) evaluated in this study, were developed in order to overcome visual limitations, reported after implantation of the traditional multifocal IOLs (such as poor visual outcome at intermediate distance range and perception of photic phenomena) based on the principle of an asymmetrical light distribution forming three (distant intermediate and near foci).^{7,9} Many studies have showed the excellent visual results after implantation of these IOLs and their ability to provide patients with spectacle independence with less chance of having disturbing photic phenomena, if any.^{4,6,13} In our study, mean monocular postoperative UDVA is 0.90 with 75% of eyes achieved ≥ 0.8 , which confirms the ability of this type of IOLs in restoring distant vision after the surgery. Furthermore, an excellent binocular UDVA of 0.96 was noticed. Our distance visual outcomes are consistent with that reported by other authors with the same type of IOLs (Table 6).^{5–7,13–22}

Regarding UNVA, the visual outcome was excellent. The mean of monocular postoperative UNVA was 0.91 where

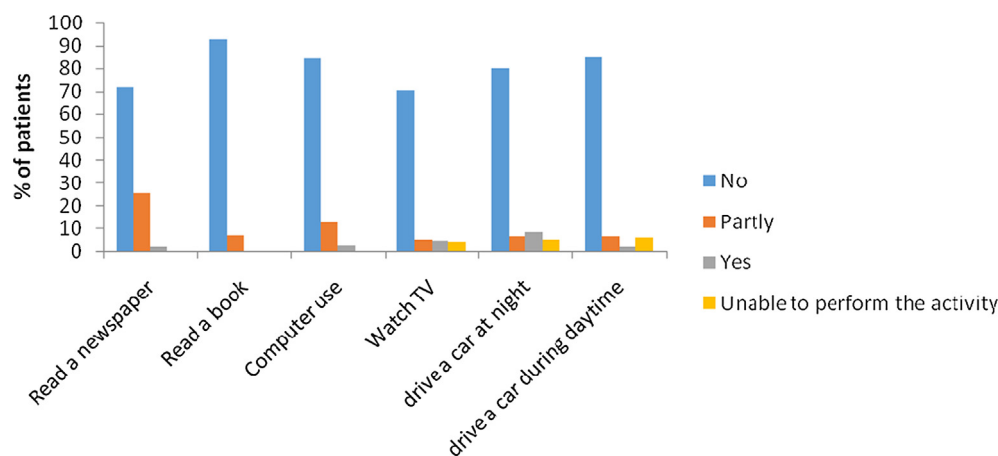


Fig. 4. Patient responses toward performing activities postoperatively.

63.4% of eyes achieved 1.0 and 90.4% of eyes achieved ≥ 0.8 when measured at 40 cm. Binocular UNVA was 0.92. This proves that this IOL design can provide an excellent near vision to patients, by either cataract extraction or refractive lensectomy. Our results are comparable with the results which obtained by Kretz et al.,^{6,23} and better than those obtained in other studies^{5,7} (Table 6). Discrepancy in the outcome among the studies have been attributed to many factors including patient selection and different examination protocols used to measure the near visual acuity.²³ It is worthwhile to emphasize that there was no significant postoperative residual myopic refraction biasing the outcome of near visual acuity as the mean postoperative SE in both cataract and refractive groups was -0.04 and -0.14 , respectively. This result is consistent with the result which is obtained by Kretz et al. with a mean postoperative SE of $+0.2 \pm 0.3$.²³

The importance of intermediate vision cannot be over emphasized especially in our modern life as this range of vision is important for many daily activities including, but not limited to, computer use. The manufactures of this IOL design put into consideration, that the traditional multifocal IOLs were not able to restore the intermediate vision, so they have developed this diffractive trifocal AT LISA platform to provide excellent intermediate vision without compromising distance and near vision. Mendicute et al. referred to that any distance between 40 cm and 100 cm is considered as intermediate vision, however there is no clear definition of intermediate vision.⁴ In our study, 66 cm was chosen as intermediate vision because it has already been used in other publications.^{5,6,23} Regarding the intermediate visual outcome, the mean postoperative monocular UIVA in our study was 0.87 and binocularly was 0.88 with almost 50% of eyes achieved 1.0 and 81.7% of eyes achieved ≥ 0.8 . Our outcome is slightly better than other authors reports^{5,6,23} (Table 6). Our results showed that this IOL design can provide patients with uncorrected intermediate vision at least as good as near and distance vision. In one comparative study, when compared with AT LISA bifocal IOLs, trifocal AT LISA showed significantly better intermediate vision (postoperative UIVA at 66 cm: trifocal 0.84 versus bifocal 0.52).¹⁵

Predictability

Mean postoperative SE refraction for cataract and refractive groups who underwent implantation of trifocal AT LISA

839MP was -0.04 and -0.14 D, respectively. This was not significantly different from the target refraction which was closest to emmetropia. Almost 87.5% of patients were within ± 0.50 of intended correction which reflects the excellent refractive predictability of this model of trifocal IOLs. Our predictability results are consistent with that reported by Kretz et al. and Mendicute et al.^{4,6} Regarding patients with toric model, the level of predictability was good with the mean postoperative SE of -0.37 with all eyes have a value within 1.00 D which is consistent with other studies evaluated the same type of IOLs.²³

Ability to perform daily activities, patient overall satisfaction and spectacle independence

Most of the studies used a self-developed questionnaire to evaluate the level of difficulty in performing some vision-related tasks after IOL implantation. In our study, we used a validated Visual Function Index questionnaire (VF-14) for the subjective assessment of visual function and patient satisfaction. Near, intermediate and far visions were assessed in this questionnaire. The mean of VF-14 score increased from a score of 50 after a month of surgery to the total score of 72 by the third month, which might reflected at early postoperative visual symptoms. The unmet patients' expectations will improve over time and premature decisions (such as IOL exchange) should be avoided.

Most of the postoperative patients had no trouble in performing tasks such as reading a book or a newspaper, working on the computer, watching TV, driving at daylight or night. And only <25% reported partial difficulty in performing their daily activities, with reading a newspaper which had the highest partial difficulty rate among them. Likewise, Kretz et al. found that 96% of his subjects were able to perform daily activities with no difficulties, and only two patients (4%) reported partial difficulty in performing their daily activities following surgery.⁶ With implantation of this evaluated IOL, the spectacle independence was highly achieved with 92% of patients have ditched their glasses for good. Anyhow, 2 patients still use their spectacle for distant vision even after 3 months passed, and only 1 patient still uses it for intermediate vision. None of our patients used their spectacles for near vision activity after the surgery.

Hamid et al. 2016 compared the visual and refractive outcomes, patient satisfaction and spectacle independence

Table 5. Patients satisfaction, spectacle independence and photic symptoms.

Category	1 st Month N (%)	3 rd Month N (%)
<i>Are you satisfied with your sight at the moment?</i>		
Very dissatisfied	0	0
Fairly dissatisfied	1(2.4)	0
Fairly satisfied	24(58.5)	4(9.7)
Very satisfied	16(39.0)	37(90.24)
Cannot decide	0	0
<i>Willingness to undergo surgery again</i>		
I will	39(95.1)	41(100)
I will not	2(4.8)	0
<i>Willingness to recommend surgery to others</i>		
I will	40(97.5)	41(100)
I will not	1(2.2)	0
<i>Are you using spectacle after surgery?</i>		
Yes, wearing for distant vision	4(9.7)	2(4.8)
Yes, wearing for intermediate activity (computer use)	2	1(2.4)
Yes, wearing for near vision	0	0
Not wearing spectacle	35(85.3)	38(92)
<i>Did you feel any of the following?</i>		
Glare	9(21.9)	2(4.8)
Halo	27(65.8)	14(34.1)
Starburst	1(2.4)	1(2.4)
Blurred vision	2(4.8)	1(2.4)
<i>Do you find these symptoms disturbing?</i>		
	(n=39)	(n=18)
Yes	2(5.1)	0
No	37(94.8)	18(100)

Table 6. Comparison of our monocular outcomes to those obtained by previous authors using same trifocal IOL modality. IOL = intraocular lens; AL = axial length; UDVA = uncorrected distance visual acuity; CDVA = corrected distance visual acuity; UNVA = uncorrected near visual acuity; UIVA = uncorrected intermediate visual acuity.

Author (year)	Eyes	AL (mm)	IOL (follow-up)	UDVA in decimal	CDVA in decimal	UNVA in decimal	UIVA in decimal
Mojzis et al. (2014) ⁴	60	–	AT LISA tri 839 MP (6 mon)	1.1 ± 0.09	1.17 ± 0.08	0.64 33 cm	0.84 ± 0.10 66 cm
Law et al. (2014) ⁵	60	20.96 ± 25.88	AT LISA tri 839 MP (6 mon)	0.9 ± 0.07	1.05 ± 0.05	0.74 40 cm (binocular)	–
Kretz et al. (2016) ⁶	100	23.92 ± 1.29	AT LISA tri 839 MP (3 mon)	0.9	0.95	0.9 40 cm	0.83 66 cm
Our study (2017)	82		AT LISA tri 839 MP AT LISA toric 939 MP (n = 8 eyes) (3 mon)	0.90	0.95	0.91 40 cm	0.87 66 cm

among three novel designs of diffractive IOLs for 150 patients.²⁴ Of which he recorded that all patients with the trifocal IOLs were reported to be spectacle-free for any distance. As such, Mendicute et al. reported that almost 90% said, they do not need spectacles for any distance.⁴ Patient satisfaction after implantation of the evaluated trifocal IOL was as high as 100% in our study and all patients would recommend the same IOL type to others. The results are consistent with that of Kretz et al.²³

The perception of photic phenomena is more common after implantation of diffractive multifocal IOLs compared with monofocal IOLs. Halos were reported in 63% in our study after the 1st month, with reduction to 36.9% after the 3rd month, during which all patients (100%) said they were not disturbing or disabling. Similar results were found by Kretz et al. of halos decreasing from 90% to 50% in the 3rd month after surgery, of them, 80% did not perceive them as disturbing.²³ This study is limited by the lack of a control group of patients with either monofocal IOLs or another type of multifocal IOLs, and the lack of objective assessment of contrast sensitivity changes. Also, corrected near visual acuity (CNVA) and corrected intermediate visual acuity (CIVA) were not assessed postoperatively in order to address any residual refractive error that might affect the final visual outcome. In addition, the inclusion of patients with toric trifocal IOLs is another drawback but the decision to include them was made in order to avoid reduction in sample size. Finally, the use of non-validated questionnaire based on direct questioning to assess the level of spectacle independence and photic phenomena.

In conclusion, the implantation of either AT LISA tri 839MP or AT LISA toric 939 MP, following cataract extraction or refractive lensectomy can provide patients with excellent spectacle-free distance, intermediate and near vision. In addition, it is associated with a good refractive predictability and some level of non-disturbing photic phenomena presumably because of the phenomena of neuronal adaptation. The results of IOLs such as good visual outcomes, spectacle independence and non-disturbing photic symptoms altogether led to high levels of patient satisfaction.

Conflict of interest

The authors declared that there is no conflict of interest.

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