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Assessment of Safety, Efficacy and Predictability of a Trifocal Intraocular Lens. Performance of PanOptix Trifocal Versus Monofocal IOL

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ABSTRACT **Ophthalmology in Russia. 2023;20(4):656–663**

Purpose. To evaluate the performance and the visual outcomes of Acrysof PanOptix trifocal IOL in terms of safety, efficacy, predictability and assessment of the quality of vision after implantation as regards; contrast sensitivity and ocular aberrations. **Methods.** A prospective interventional non randomized study that included forty eyes of twenty one patients with senile cataract. All surgeries were carried out between September 2019 and January 2020. Patients underwent phacoemulsification for cataract removal with IOL implantation. They were divided into two groups; group(A) included twenty eyes of eleven patients who were implanted with AcrySof IQ PanOptix trifocal IOL Model TFNT00. While group (B) included twenty eyes of ten patients who were implanted with monofocal AcrySof IOLs as a control group. **Results.** There were 21 subjects enrolled in our study. Mean age was 56.6 ± 6.9 years in group (A) and 62.8 ± 7.1 years in group (B),(range 50–70).We found statistical significant difference between both groups with group A showing better post operative uncorrected distance, intermediate, near, and best corrected near visual acuity . Group (B) showed statistically significant better post operative contrast sensitivity compared to group (A). Conclusion: In this study, Acrysof PanOptix trifocal IOL showed excellent safety, efficacy, predictability and spectacle independence at all distances, This prospective interventional non-randomized study showed excellent safety, efficacy and predictability of the PanOptix IOL with higher spectacle independence, slightly impaired contrast sensitivity without affecting daily activities. However, contrast sensitivity was compromised in comparison to the monofocal group and high order aberrations (coma, trefoil) were noted to be higher affecting the quality of vision but not the daily activities of the patient.

Keywords: Acrysof PanOptix trifocal IOL, monofocal IOL, quality of vision, contrast sensitivity, ocular aberrations

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Оценка безопасности, эффективности применения трифокальной интраокулярной линзы. Сравнение эффективности ИОЛ PanOptix и монофокальной ИОЛ

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РЕЗЮМЕ

Офтальмология. 2023;20(4):656–663

Цель: оценить эффективность результатов применения трифокальной ИОЛ Acrysof PanOptix с точки зрения безопасности, эффективности, предсказуемости результатов и оценки качества зрения после имплантации; контрастную чувствительность и аберрации. **Методы.** Проспективное интервенционное нерандомизированное исследование, включавшее 40 глаз 21 пациента со старческой катарактой. Все операции были проведены в период с сентября 2019 по январь 2020 г. Пациентам проведена факоэмульсификация катаракты с имплантацией ИОЛ. Пациенты были разделены на две группы; группа А включала 20 глаз одиннадцати пациентов, которым была имплантирована трифокальная ИОЛ AcrySof IQ PanOptix модели TFNT00. Группа Б была контрольной и включала 20 глаз десяти пациентов, которым была имплантирована монофокальная ИОЛ AcrySof. Средний возраст составил 56,6 ± 6,9 года в группе А и 62,8 ± 7,1 года в группе Б (диапазон 50–70 лет). **Результаты.** Обнаружено статистически значимое различие между обеими группами, причем в группе А получены более высокая послеоперационная острота зрения без коррекции вдаль, на промежуточном, с коррекцией на близком расстоянии. В группе Б имела место статистически значимо лучшая послеоперационная контрастная чувствительность по сравнению с группой А. **Выводы.** В исследовании продемонстрирована высокая безопасность, эффективность, предсказуемость и независимость от очков на всех расстояниях при использовании трифокальной ИОЛ Acrysof PanOptix. Однако отмечена несколько сниженная контрастная чувствительность по сравнению с группой Б (монофокальная ИОЛ), что не влияло на повседневную деятельность пациента. Было отмечено, что аберрации высокого порядка (кома, трефойл) больше влияли на качество зрения, но не на повседневную деятельность пациента.

Ключевые слова: трифокальная ИОЛ Acrysof PanOptix, монофокальная ИОЛ, качество зрения, контрастная чувствительность, абберации

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Конфликт интересов отсутствует

INTRODUCTION

Nowadays, with the expansion of indications for lens removal including refractive lensectomy in younger ages, the demand for intraocular lenses (IOLs) has increased. One of which is; spectacle independence for presbyopes and a superb visual performance on various distances of sight. Bifocal IOLs provide satisfactory visual acuities for near and far distances albeit with compromise of intermediate vision.[1] The development of trifocal IOLs addresses this problem and provides good results that are reported by several authors previously.[2] Despite the varied numbers of economic multifocal IOLs available in today's market, most of them are supported diffractive platforms that use slightly different focal points for far, intermediate, and near activities. The new Acrysof PanOptix trifocal IOL seeks low pupillary dependence and aims to improve intermediate vision with a substantial range and an optimal one at 60 cm,[3] which is the distance most used recently in daily life with the massive development and rising usage of handheld devices and computers. The new AcrySof PanOptix trifocal IOL has been developed to improve light transmission and distribution between the three focuses.

Our aim is to evaluate the performance and the visual outcome of Acrysof PanOptix trifocal IOL in terms of safety, efficacy, predictability and assessment of the quality of vision after implantation as regards; contrast sensitivity and ocular aberrations. PanOptix is a trifocal IOL, with overall length 13 mm, apodised 4.5 mm diffractive optical zone that features an optical technology designed to help patients adjust more naturally to their new vision by providing a range of near to intermediate vision (40–80 cm) with a crisp focal point at 60 cm and by optimizing light transmission to the retina.[4] This lens is made from a hydrophobic acrylic material with a 6.0 mm optical diameter, comprising a central 4.5 mm region with 15 diffractive rings and an outer annulus that is refractive only. The lens is a quadrifocal diffractive design, but the light from the first diffractive order is redistributed to the distance (refractive order) and second diffractive order using proprietary technology. The lens has the necessary diffractive design feature of multiple harmonics, with lens add powers of +1.1, 2.2 and 3.3 D at the IOL plane; it is the 1.1 D diffractive order that is redistributed. This lens design provides

approximate focal points of 60 and 40 cm for the intermediate and near foci, respectively.

At a 3 mm pupil diameter, it transmits 88 % of light to the retina, which is higher than other traditional trifocal multifocal IOLs, like FineVision(PhysIOL) and the AT LISA tri 839 (Zeiss). The PanOptix Acrysof has non-apodised new trifocal design that redirects light from the 3rd step height to distance.[5]

METHODS

This is a prospective non-randomized interventional study that was conducted out in Dar el Ouyon hospital and Rowad Correction Center, between September 2019 and January 2020, in Cairo, Egypt. The study included patients older than 50 years old and younger than 70 years old with cataract and decreased best corrected visual acuity seeking spectacle independence with easy going personality and no abnormality detected by fundus examination or history of retinal surgery. The study excluded any patient with corneal opacity, astigmatism more than 1.5 dioptre, glaucoma, previous attack of iridocyclitis , narrow or decentred pupil, history of previous refractive surgery, single seeing eye, zonular weakness especially pseudoexfoliation, any abnormality of the optic nerve that restricts potential visual acuity, contrast sensitivity, colour perception, or field of vision, alternating monofixations, such as patients with a large angle alternating strabismus, large angle Kappa, moderate and severe dry eye, intraoperative anterior capsule tear. intraoperative smaller capsular opening than 5.5 mm or decentred capsulorhexis.

Routine history recording of each patient included: age at the time of presentation, gender, history of ocular disease. Clinical assessment of subjects included: measurements of Snellen visual acuity; monocular unaided, binocular unaided and optimal corrected distance visual acuity CDVA (with the best manifest correction), uncorrected intermediate visual acuity, best corrected intermediate visual acuity at 60 cm, uncorrected near visual acuity and optimal corrected near visual acuity at 30–40 cm. Slit-lamp biomicroscopy examination was performed to examine anterior and posterior segment. Corneal topography: using the Oculus Pentacam Scheimpflug crosssectional imaging for group (A). Biometry: preoperative biometry was done to calculate the IOL power using the Barrett Universal II formula in both groups. All patients were adjusted to achieve postoperative emmetropia.

Postoperative evaluation included: Evaluation of visual acuity: UCDVA, BCDVA were measured binocularly and monocularly using Snellen chart. Decimal values of visual acuity were converted into logMAR. UCIVA, BCIVA were measured at a distance 60 cm using Snellen chart. UCNVA and BCNVA were evaluated using Jaeger's chart at a distance between 30-40 cm then converted to logMAR. Assessment of contrast sensitivity was done by using the Pelli Robson chart, refraction, slit lamp examination was done for the assessment of: corneal edema, anterior chamber reaction, IOL centration and PCO, applanation tonometer was used to measure the IOP, fundus examination, aberrometry using the VisxiDesignWavescan (USA) was done 2 months later, in addition, quality of vision questionnaire (5 items) was done 2 months later.

Scoring of Pelli-Robson chart. The score of the test was recorded by the faintest triplet out of which at least 2 letters are correctly identified, the log CS value of this triplet was given by the number on the scoring pad. Values< 1 log CS indicates visual impairment, values between log 1.00 to log 1.5 indicates decreased CS, while values between log1.5 to log 2.00 indicates normal visual contrast sensitivity.

Visx iDesign aberrometry. VisxWavescan (iDesign STAR 4IR) was used in our study (Figure 1) to measure the refractive error and wavefront aberrations of the human eye using a Hartmann-Shack wavefront principle and representation of peripheral data using a multi term polynomial.[6]

Questionnaire (QoV). The patient's vision postoperatively, was assessed using this questionnaire, after explaining to him/her the questions in Arabic language and clarifying the aim of the evaluation or the questionnaire. The patient had enough time to read and answer all the items mentioned below autonomously, asking him/her kindly to put a tick or X in the suitable square. Our study is concerned with assessing safety, efficacy and predictability of the novel PanOptix trifocal IOL, so we evaluated the following indices as follows:

Safety: is defined as the proportion number of eyes that lost or gained one or more lines of postoperative BCVA relative to the preoperative BCVA. Safety index: is defined as mean BCVA ÷ mean preoperative BCVA. Efficacy: is defined as the proportion number of eyes achieving an UCVA of 20/20 or better postoperatively. Efficacy Index: is defined as mean postoperative UCVA ÷ mean preoperative BCVA. Predictability: is defined as the proportion

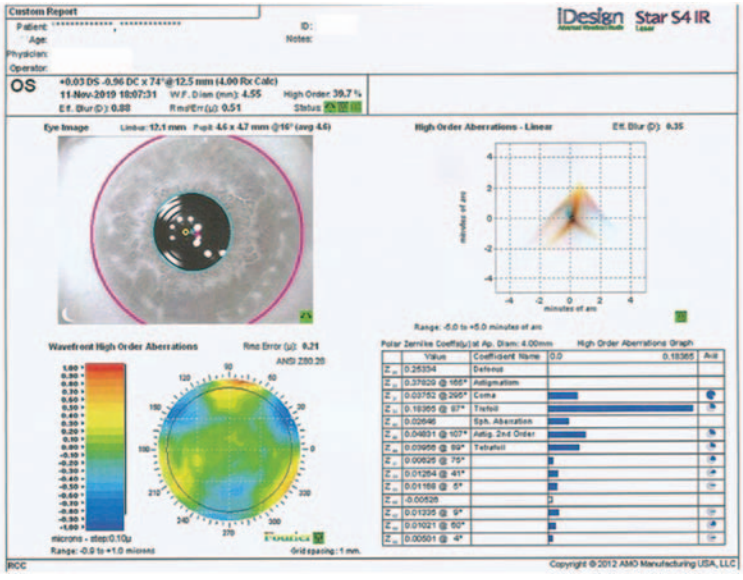

Fig. 1. Visx iDesign aberrometry. VisxWavescan (iDesign STAR 4IR)

Рис. 1. Аберрометрия Visx iDesign. VisxWavescan (iDesign STAR 4IR)

number of eyes achieving a postoperative SE within ± 0.50 D of the intended target refraction.

Statistical Analysis. The collected data were revised, coded, tabulated and introduced into a PC using statistical package for social science. (Statistical Package for the Social Science; SPSS Inc., Chicago, IL, USA) version 22 for Microsoft Windows. Data is presented as mean and standard Deviation (± SD) for quantitative parametric data, or frequencies (number of cases) and percentages when appropriate. Comparison of numerical variables between the study groups is done using Mann Whitney *U* test for independent samples. For comparing categorical data, Chi square (χ^2) test is performed. Exact test is used instead when the expected frequency is less than 5. Comparison over time between preoperative and post-operative in group (A) is done by paired *t* test. All visual acuity results are converted to logMAR units. Contrast sensitivity is presented as logCS units. Wilcoxon signed ranks test is used also to compare two related samples or matched samples. Pie charts are used to show or illustrate the proportional and percentage data. Multiple linear regression analysis is used to predict the value of a variable based on the value of two or more other variables. Pearson`s correlation coefficient is used also to show the relation between two quantitative continuous variables. All p values are two sided. *P* values ≤ 0.05 are considered significant. We used the following formula for a CI for a population proportion: 20 eyes, under the Poisson model :

$$n_c = n_1 - e^{-\Lambda}.$$

Where n_c is the number of cases requires, Λ is the observational period, *n* — number of events.

Table 1. VA of both groups in LogMAR

Таблица 1. Острота зрения обеих групп LogMAR

	Group (A) mean values	Group (B) mean values	*P value*
Post UCDVA	0.06	0.4	*0.001*
Post BCDVA	0.08	0.1	*0.556*
Post UCIVA	0.0	0.3	*0.001*
Post BCIVA	0.0	0.0	*0.177*
Post UCNVA	0.0	0.7	*0.001*
Post BCNVA	0.0	0.1	*0.001*

Table 2. Pre and post operative VA values in group (A) in LogMAR

Таблица 2. Показатели остроты зрения до и после операции в группе (A) LogMAR

	Mean value		Mean value	*P value*
Pre op.UCDVA	0.62	Post op. UCDVA	0.06	*0.001*
Pre op.BCDVA	0.42	Post op. BCDVA	0.08	*0.001*
Pre op.BCDVA	0.42	Post op. UCDVA	0.06	*0.001*
Pre op.UCIVA	0.57	Post op. UCIVA	0	*0.001*
Pre op.BCIVA	0.42	Post op. UCIVA	0	*0.001*
Pre op.UCNVA	0.63	Post op. UCNVA	0	*0.001*
Pre op. BCNVA	0.3	Post op. UCNVA	0	*0.001*

RESULTS

Males represented 50 % of patients and females represented 50 % of patients in group (A). Males represented 30 % of patients and females represented 70 % of patients in group (B). We found statistical significant difference between both groups considering post UCDVA, UCIVA, UCNVA, BCNVA (Table 1).We found statistical difference between pre operative and post operative UCDVA, BCDVA, UCIVA, BCIVA, UCNVA, BCNVA (Table 2). Results showed significant statistical difference between postoperative contrast sensitivity mean values between both groups (Table 3).

QUESTIONNAIRE (QOV) RESULTS

In group (A) 1 patient (10 %) was not satisfied with far and night vision 50 % of patients experienced glare and halos, while 100 % of patients were satisfied with intermediate and near vision. In group (B) 100 % of patients were satisfied with far, intermediate, near vision and night vision with glasses and no one experienced glare or halos (Table 4). Total HOA % was noted to be higher in group (A) than group (B), coma and trefoil had the highest mean values in group (A), While trefoil had the highest mean in group (B) (Tables 5, 6).

Multiple linear regression analysis revealed significant direct correlations between postoperative primary coma and postoperative total HOA % (r = 0.67, p = 0.002) and significant direct correlation between postoperative trefoil and total HOA % (r= –0.52, p = 0.02) (Fig. 2, Table 7). In group (B), multiple linear regression analysis revealed significant direct correlations between postoperative trefoil, and total HOA % (r = 0.574, p = 0.008) (Fig. 3, Table 8). Safety 2 eyes gained 8

Table 3. Pre and post operative contrast sensitivity values in both groups in logCS

Таблица 3. Значения контрастной чувствительности до и после операции в обеих группах в logCS

Group (A)	Mean value	Group (B)	Mean value	*P value*
Post op. mesopic CS	1.19	Post op.mesopic CS	1.55	<0.001
Post op. photopic CS	1.27	Post op.photopic CS	1.63	<0.001

Table 4. Frequency table showing the results of the questionnaire in group (A).

Таблица 4. Результаты анкетирования в группе (A)

Item of the questionnaire	Patient`s answer	No. of patients	Percent
Satisfaction with far vision	Satisfied	9	90
	Not satisfied	1	10
Satisfaction with intermediate vision	Satisfied	10	100
	Not satisfied	0	0
Satisfaction with near vision	Satisfied	10	100
	Not satisfied	0	0
Satisfaction with night vision	Satisfied	9	90
	Not satisfied	1	10
Experienced glare/halos	Yes	5	50
	No	5	50

Table 5. Post operative aberrations in both groups

Таблица 5. Послеоперационные аберрации в обеих группах

Coefficient value for each Zernike term	*Group (A)*	Mean	Maximum	Minimum	SD
Z_4^0	2ry spherical aberration	0.023	0.06	0.002	±0.01
Z_3^1	Coma	0.068	0.2	0.001	±0.05
Z_4^2	2ry Astigmatism	0.021	0.06	0.002	±0.01
Z_3^{-3}	Trefoil	0.079	0.2	0.002	± 0.04
Z_4^4	Tetrafoil	0.044	0.097	0.001	±0.03
	Group (B)				
Z_4^0	2ry spherical aberration	0.07	0.36	0.11	±0.07
Z_3^1	Coma	0.14	0.46	0.14	±0.11
Z_4^2	2ry astigmatism	0.03	0.07	0.005	±0.02
Z_3^{-3}	Trefoil	0.12	0.29	0.02	±0.07
Z_4^4	Tetrafoil	0.06	0.15	0.016	±0.04

lines, 3 eyes gained 5 lines, 4 eyes gained 4 lines 4 eyes gained 3 lines, 1 eye gained 2 lines of post operative BCVA, and no patients lost any lines, so the safety index is 2 in group (A). Efficacy 8 eyes gained 8 lines, 2 eyes gained 6 lines, 2 eyes gained 5 lines, 2 eyes gained 4 lines, 2 eyes gained 1 line, 1 eye gained 3 lines, 1 eye gained 2 lines of post operative UCVA and no patients lost lines, so the efficacy index is 2.1 in group

Table 6. Mean values of HOA, RMS error, Effective blur in both groups

Таблица 6. Средние значения аберраций высшего порядка, среднеквадратичное отклонение, сглаживание по Гауссу в обеих группах.

	Group A		Group B		
	Mean	(range)	Mean	(range)	*p value*
HOA %	44.27	(15.3-91)	25.83	(13.5-69.9)	*0.02*
RMS error	0.42	(0.17-0.78)	1.01	(0.54-1.96)	*<0.001*
Effective blur	0.64	(0.18-1.34)	1.2	(0.17-3.37)	*0.01*

(A). Predictability: 16 eyes (88 %) achieved post operative SE within ± 0.5 D ingroup (A). No intraoperative complications, all surgeries were uneventful.

POSTOPERATIVE COURSE

Two patients were excluded from the study from group (A), a male patient who had his IOL explanted two weeks postoperative and did not continue the follow up due to his complaint of bad quality of vision in spite of the good visual acuity including far, intermediate and near vision but, intolerable presence of glare and halos as he described the worst ever. The other patient underwent bilateral implantation of the IOL, but her left eye did not improve after cataract surgery owing to her deep amblyopia discovered postoperatively, she

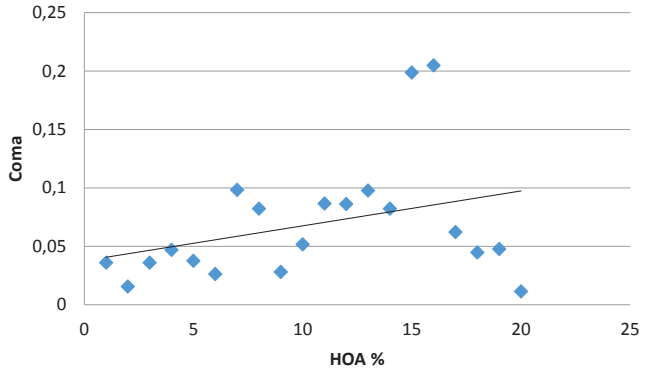

Fig. 2. Scatter dot diagram showing the direct correlation between coma and HOA % in group (A)

Рис. 2. Диаграмма, отражающая прямую корреляцию между комой и процентом аберраций высшего порядка в % группе (А)

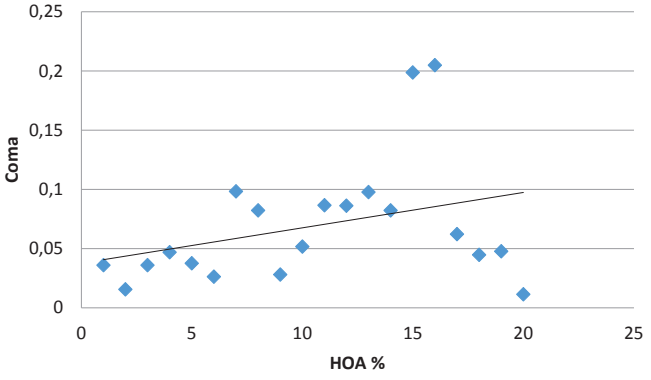

Fig. 3. Scatter dot diagram showing the direct correlation between trefoil and HOA % in group (B)

Рис. 3. Диаграмма, отражающая прямую корреляцию между комой и процентом аберраций высшего порядка в % группе (В)

Table 7. Pearson correlation between different aberrations and HOA % group (A)

Таблица 7. Корреляция Пирсона между различными аберрациями и аберрациями высшего порядка % (А)

	HOA %	
	Pearson Correlation	*p value*
Coma	0.674	*0.002*
Trefoil	0.525	*0.02*
Tetrafoil	0.414	0.08
2ry Spherical aberration	-0.358	0.1
Astigmatism 2nD order	0.037	0.88

Table 8. Pearson correlation of different aberrations to HOA

Таблица 8. Корреляция Пирсона между различными аберрациями и аберрациями высшего порядка % (В)

	HOA %	
	Pearson Correlation	*p value*
Trefoil	0.574	*0.008*
Spherical aberration	0.38	*0.09*
Astigmatism 2nd order	-0.046	*0.84*
Tetrafoil	0.032	*0.89*
Coma	0.081	*0.7*

was excluded from the contrast sensitivity assessment and therefore form our study.

DISCUSSION

Trifocal IOLs achieve a wide range of vision by using different optical designs and technologies, studies have shown that, in general, these trifocal IOLs provide good VA at all distances, high patient satisfaction, and spectacle independence.[7] In our study we compared the quality of vision after implanting PanOptix IOL, apodised diffractive aspheric trifocal IOL and Acrysof monofocal IOL following cataract extraction regarding the visual acuity (distance, intermediate and near vision), contrast sensitivity, (mesopic and photopic), and the aberrations induced postoperatively. In this study, group (A) the PanOptix trifocal IOL showed excellent safety, efficacy and predictability. Considering safety in group (A), preoperative mean logMAR of BCVA was 0.42 while postoperatively, it was 0.08, which was statistically significant, there was no increase in the intraocular pressure or visual threatening complications, in addition, no patients have lost lines of BCVA postoperatively. Considering efficacy in group (A), no patient had UCDVA worse than 0.2 and 100 % of patients included in the study gained lines postoperatively. Comparing between the UCDVA mean values preoperatively and postoperatively in group (A), the uncorrected distance vision improved postoperatively.

Concerning predictability in both groups, emmetropia was the target of ourstudy, both groups had a favorable tendency toward emmetropia at 2 months postoperatively. Considering the intermediate and near vision 100 % of patients did not need any add correction postoperatively in group (A), while in group (B) the BCNVA mean value was 0.11 after adding the needed add correction according to age in all patients. In group (A) both intermediate and near vision improved post operatively and the difference between preoperative and postoperative was statistically significant. In addition, there was no significant statistical difference between postoperative BCDVA between both groups. We observed similar results in previous studies done by Alió et al, Kohnen et al, Lawless et al and García-Pérez et al.[8,9,10,11] (Table 9). Similar to our study, Alió[8] in 2018 reported significant improvement in uncorrected VA results 1 month after implantation, and the VA remained stable through the 6 month follow up period. In addition, Kohnen[9] in 2017 reported better UCIVA results measured at 60 cm than VA measured at 80 cm, as he measured both distances, which is like our results as we measured UCIVA at 60 cm and the mean value was 0. Similar to our study, García-Peréz[10] in 2017 reported excellent visual outcomes in patients implanted with PanOptix IOL during the 1 month follow up period, all patients achieved binocular uncorrected visual acuity better than 20/40 Snellen equivalent, in our study 100 % of patients achieved visual acuity better than 20/40 for distance and near vision. Regarding the satisfaction with near vision, 100 % of patients in our study were satisfied with their near vision with no add correction needed, like the results of Alió[8] in 2018 whose study documented near vision satisfaction improved after the surgery. During the period of follow up, contrast sensitivity was evaluated in both groups using Pelli-Robson chart, this test is easy to be interpreted and reliable. The monofocal group (B) achieved higher levels of contrast sensitivity than group (A). Also preoperative contrast sensitivity values were higher in group (A) than postoperative values, the difference was statistically significant which indicates that contrast sensitivity was affected by implanting the PanOptix trifocal IOL. Our results are consistent with the work of Alió[8] in 2018 who studied the contrast sensitivity also by Pelli-Robson chart and obtained low CS values after Panoptix IOL implantation. In consistent with the work of Gundersen and Potvin[12] in 2017, binocular distance low contrast sensitivity values were obtained when comparing the performance between two different designs (FineVision and PanOptix). Considering the questionnaire, in group (A), 1 patient (10 %) was not satisfied with far vision and night vision, While 100 % of patients were satisfied with intermediate vision and near vision, 50 % of patients experienced halos and glare which indicate that PanOptix trifocal IOL achieved excellent results with visual acuity and spectacle independence, though visual quality was affected in number of patients who reported seeing glare and halos, in group (B) 100 % of patients did not have any problems either halos or glare or any problems with night vision and were satisfied with far, intermediate and near vision with their glasses. Our results showed 100 % spectacle independence, in contrast to the results of García-Peréz[10] in 2017, although all patients in his study were able to perform daily tasks without spectacle correction, one patient reported using spectacles occasionally for all distances, he used the Catquest9-SF questionnaire. In addition, Kohnen[9] in 2017 reported complete spectacle in dependence was achieved by 96 % of patients with only 1 patient reported the use

Table 9. Summary of visual and refractive results in previous studies done on PanOptix trifocal IOL

Таблица 9. Суммарные визуальные и рефракционные результаты предыдущих исследований, проведенных с использованием трифокальной ИОЛ PanOptix

	Number of eyes	Follow up months	Mean postop. SE	Mean postop. UCDVA	Mean post op UCIVA	Mean post op UCNVA
Alió 2018 [8]	52	6		0.08	0.13	0.18
Kohnen 2017 [9]	54	3	-0.04	0	0	0.1
Lawless 2017 [11]	66	2	-0.08	0.01	0.3	0.18
García-Pérez 2017 [10]	116	1	-0.1	0.03	0.12	0.02
Our study	18	2	-0.11	0.06	0	0

of spectacles for far distance. High patient satisfaction and spectacle independence were reported with PanOptix, but in contrast to our study, there were no reports of patients opting for lens exchange due to photopic phenomena in any of the studies, while in our study, one patient chose to have lens exchange after implanting PanOptix 2 weeks postoperatively due intolerable glare and halos that he experienced and was excluded from the study. In our study 50 % of the patients suffered glare and halos without impairing their daily activities, while Kohnen in 2017 reported that 93 % of patients experienced an optical phenomena, 89 % halos, 11 % glare, 7 % double vision, 4 % ghosting and distorted vision that was reported using a short quality of vision (QoV) questionnaire (19 items) which was used to assess patient reported outcomes based on presence of visual disturbances, life style activities, and spectacle independence. Similarly, results obtained by Mennuci[13] in 2018 in a comparative study, as patients reported that halos and glare were the most frequently reported visual disturbances, although the symptoms were rated mostly as mild or not affecting their daily activities. The reported incidence of halos showed a wide variation among the studies ranging from <1 % to 89 %. In contrast to our study, Lawless[11] in 2017 reported only 15 % of patients experienced halos of moderate severity in the early postoperative period but it did not impair their activities, and the complaint diminished by the subsequent postoperative follow up. Cochener[14] in 2018 performed the QoV questionnaire and only <1 % of patients reported nighttime visual disturbances, dry eye, halos, and glare. Outcomes obtained in our study are similar to studies with more than one month follow up period as in Sheppard`s cohort study in 2013.[15] Considering the assessment of aberrations in group (A), postoperatively, we found that coma ($Z3^{1}$) and trefoil ($Z3^{-3}$) had the highest values with significant direct correlation to the total high order aberrations percentage. These results of the high order aberrations are consistent with our questionnaire results, as coma and trefoil have high mean values in group (A), both affect the quality of vision more than the acuity of vision,[16] which explains the high percent of patients who complained of glare and halos in the questionnaire in group (A) without affecting their daily activities, and deterioration of contrast sensitivity in comparison to group (B), in which, only trefoil had a high mean value and a significant correlation to total high order aberrations which is less than group (A). The difference between HOA % post operatively between both groups was statistically significant. In our study, effective blur was higher in group (B) than group (A), we explained this higher value in group (B) due to the higher values of low order aberrations as defocus and astigmatism than group (A). Similar to our CS, and aberrations results, a study done by Chung Yeom Kim[17] in 2007 concluded that high order aberrations, especially spherical aberrations, were increased significantly in the multifocal IOLs ingeneral compared with the monofocal IOL group. Regression analysis revealed a strong correlation between high order aberrations, such as coma and secondary spherical aberration, and CS values. However, optical aberrations analysis did not show a significant difference in coma aberrations between the monofocal and the multifocal IOL groups, suggesting that spherical aberrations induced by multifocal IOLs contribute more to the reduction in CS than coma aberration does. In our study, all surgeries were uneventful. Regarding the adverse postoperative events, one patient had his PanOptix trifocal IOL explanted due to intolerable glare and halos and was excluded from the study. PCO usually has a delayed manifestation and can appear years after the cataract surgery[18]. The incidence of PCO and Nd: YAG rates were nil in our study, in contradiction to the study of García-Peréz in 2017, he recorded one case of PCO in 1 month follow up study, consistent with this finding, Kacerovsky[19] in 2018 observed the PCO rate to be 0.5 % with PanOptix implantation. All other reviewed and published studies had a maximum of 6 months postoperative evaluation period, which is insufficient to determine the true incidence of PCO. Thus, long term follow up studies are recommended, also studying the aberrations induced by the IOL by other aberrometers like OPD-Scan II, iTrace, Schwind Peramis, CSO Sirius over a longer period of time of follow up could give us more information about the aberrations induced by PanOptix that affect the quality of vision. The limitations of our study are; the limited sample size and the relative short time of the follow up.

CONCLUSION

In this study, Acrysof PanOptix trifocal IOL showed excellent safety, efficacy, predictability and spectacle independence at all distances. However, contrast sensitivity was compromised in comparison to the monofocal group and high order aberrations (coma, trefoil) were noted to be higher affecting the quality of vision but not the daily activities of the patient.

CONCLUSIONES

Multifocal IOLs offer to the patients spectacle independence in both distant and near work, with compromised intermediate work.

What this paper adds

Panoptix trifocal IOL offered excellent compliance of patients at distant, near, and intermediate work.

Reduced contrast sensitivity affected quality of vision compared to monofocal IOL without affecting distant uncorrected visual acuity.

Types and kinds of high order aberrations induced after implantation of monofocal IOLs and after Panoptix trifocal IOLs using Visx idesign aberrometry

REFERENCES

1. Alió JL, Plaza-Puche AB, Férnandez-Buenaga R. Multifocal intraocular lenses: an overview. Surv Ophthalmol. 2017; 62: 611–634. doi: 10.1016/j.survophthal.2017.03.005.
2. Lawless M, Hodge C, Reich J. Visual and refractive outcomes following implantation of a new trifocal intraocular. Eye Vis. 2017;4: 10. doi: 10.1186/s40662-017-0076-8. eCollection 2017.

3. García-Pérez JL, Gros-Otero J, Sánchez-Ramos C. Short term visual outcomes of a new trifocal intraocular. BMC Ophthalmol. 2017;17:72. doi: 10.1186/s12886-017-0462-y.
4. Lee S, Choi M, Xu Z, Zhao Z, Alexander E, Liu Y. Optical bench performance of a novel trifocal intraocular lens compared with a multifocal intraocular lens. Clin Ophthalmol. 2016;10:1031–1038. doi: 10.2147/OPTH.S106646. eCollection 2016.
5. Sudhir RR, Dey A, Bhattacharrya S, Bahulayan A. AcrySof IQ PanOptix Intraocular Lens Versus Extended Depth of Focus Intraocular Lens and trifocal Intraocular Lens: A Clinical Overview. Asia Pac J Ophthalmol (Phila). 2019;8(4):335–349. doi: 10.1097/APO.0000000000000253.
6. Knapp S, Awwad ST, Ghali C, McCulley JP. Ocular aberrations measured by the Fourier based WaveScan and Zernike based Ladar Wave Hartmann-Shack aberrometers. J Refract Surg.2009;25(2): 201–209. doi: 10.3928/1081597X-20090201-05.
7. Alió JL, Plaza-Puche AB, Sala E. Impact of low mesopic contrast sensitivity outcomes in different types of modern multifocal intraocular lenses. Eur J Ophthalmol.2016;26:612–617. doi: 10.5301/ejo.5000777.
8. Alió JL, Plaza-Puche AB, Alio Del Barrio JL. Clinical outcomes with a diffractive trifocal intraocular lens. Eur J Ophthalmol. *2018*; 28:419–424. doi: 10.1177/1120672118762231.
9. Kohnen T, Herzog M, Hemkeppler E. Visual performance of a quadrifocal (trifocal) intraocular lens following removal of the crystalline lens. Am J Ophthalmol. 2017;184:52–62. doi: 10.1016/j.ajo.2017.09.016.
10. García-Pérez JL, Gros-Otero J, Sanchez-Ramos C. Short term visual outcomes of a new trifocal intraocular lens. BMC Ophthalmol.2017;17:72. doi: 10.1186/s12886-017-0462-y.
11. Lawless M, Hodge C, Reich J. Visual and refractive outcomes following implantation of a new trifocal intraocular lens. Eye Vis (Lond*)*. 2017;4:10.
12. Gundersen k, Potvin R. Trifocal intraocular lenses: a comparison of the visual performance and quality of vision provided by two different lens designs. Clin.Ophthalmology. 2017;11:1081–1087. doi: 10.1186/s40662-017-0076-8.
13. Mencucci R, Favuzza E, Caporossi O. Comparative analysis of visual outcomes, reading skills, contrast sensitivity, and patient satisfaction with two models of trifocal diffractive intraocular lenses and an extended range of vision intraocular lens. Graefes Arch ClinExpOphthalmol .2018;256:1913–1922. doi: 10.1007/s00417-018-4052-3.
14. Cochener B, Boutillie G, Lamar M. A comparative evaluation of a new generation of diffractive trifocal and extended depth of focus intraocular lenses. J Refract Surg 2018;34:507–514. doi: 10.3928/1081597X-20180530-02.
15. Sheppard AL, Shah S, Bhatt U. Visual outcomes and subjective experience after bilateral implantation of a new diffractive trifocal intraocular lens. J Cataract Refract Surg 2013; 39: 343–349. doi: 10.1016/j.jcrs.2012.09.017.
16. Applegate RA, Sarver EJ, Khemsara V. Are all aberrations equal? J Refract Surg 2002;18: S556–S562. doi: 10.3928/1081-597X-20020901-12.
17. Chung SH, Kim TI, Cho YJ, Yoon G, SeoKY.Comparison of higher order aberration and contrast sensitivity in monofocal and multifocal intraocular lenses. Yonsei Med J. 2007;48(4):627–633. doi: 10.3349/ymj.2007.48.4.627.
18. Davison JA. Neodymium: YAG laser posterior capsulotomy after implantation of AcrySof intraocular lenses. J Cataract Refract Surg. 2004;30:1492–1500. doi: 10.1016/j.jcrs.2003.11.042.
19. Kacerovsky M. PanOptix and AT LISA tri in presbyopic surgery. Presented at European Socitey of Cataract and Refractive Surgeons education forum. September 2018, Vienna, Austria.

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