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AcrySof IQ PanOptix Intraocular Lens Versus Extended Depth of Focus Intraocular Lens and Trifocal Intraocular Lens: A Clinical Overview

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Abstract: AcrySof IQ PanOptix Model TFNT00 (Alcon Laboratories, Fort Worth, TX) is a 1-piece aspheric hydrophobic presbyopia-correcting intraocular lens (IOL) launched in 2015. Unlike traditional trifocal IOLs that usually have an intermediate focal point of 80 cm, the PanOptix IOL is designed to have an intermediate focal point of 60 cm (arms-length), a more natural and comfortable working distance to perform functional tasks on computers, laptops, mobiles, among others. The non-apodized PanOptix IOL uses the ENhanced LIGHT ENergy (ENLIGHTEN; Alcon Laboratories, Fort Worth, TX) optical technology that provides high (88%) utilization of light energy, low dependence on pupil size in all lighting conditions, and a more comfortable near-to-intermediate range of vision than traditional trifocal IOLs. This review provides an overview of the clinical performance of the PanOptix IOL and discusses it in the context of other commercially available trifocal IOLs, FineVision Micro F (PhysIOL, Liege, Belgium), the AT LISA tri 839MP (Carl Zeiss Meditec AG, Jena, Germany) and the extended depth of focus IOL, TECNIS Symfony (Abbott Medical Optics, Santa Ana, CA). A literature search was performed in the PubMed database to identify studies that have assessed the visual and other clinical outcomes with the PanOptix IOL. In total, 12 studies were included in this review article. Overall, the clinical evidence suggests that in general good visual outcomes, along with a high degree of spectacle independence, are achieved in patients implanted with the PanOptix, FineVision, AT LISA and Symfony IOLs. However, every MIOL has its benefits and limitations, which along with patient's needs and clinical conditions are important factors to consider while selecting an IOL to achieve best possible postoperative outcomes.

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Cataract surgeries performed in recent times not only improve vision but also aim to enhance the patient's quality of life (QoL). The intraocular lens (IOL) used for implantation during cataract surgery plays a pivotal role in achieving the desired visual outcomes after surgery.[1] Modern day IOLs are available in a variety of materials, designs, and optic features which influence their visual performance, for example, blue light filtering, aspheric, toric, monofocal, multifocal, and accommodating IOLs.[1]

Monofocal IOLs, the most commonly used lenses for the correction of presbyopia in patients undergoing cataract surgery, have only one fixed sharp focus point (usually for distance vision).[2] As a result, most patients require the aid of corrective glasses to accomplish near and intermediate tasks. Multifocal IOLs (MIOLs) are designed to allow unaided good vision across a range of distances by providing multiple foci simultaneously. Studies have shown that MIOLs are comparable to monofocal IOLs for distance vision but are more effective for near vision and provide greater spectacle independence.[2–4] Based on the focality, MIOLs are classified as either bifocal (2 foci) or trifocal (3 foci).[5]

Trifocal IOLs provide improved intermediate vision over bifocal IOLs, a specific advantage since many day-to-day activities, such as the use of computers, laptops, and handheld devices like mobiles and tablets, require good intermediate vision in the range of 60 to 80 cm. Although MIOLs are more frequently associated with photic disturbances than monofocal IOLs, the trifocals IOLs have improved performance in photic phenomena than bifocal IOLs.[4,6,7] More recently, extended depth of focus (EDOF) IOLs, a new class of IOLs have been introduced. The EDOF IOLs elongate a single focal point over a range of distance using diffractive optics, thus providing better intermediate performance than monofocal IOLs.

In addition to fast and complete visual rehabilitation after cataract surgery, a significant factor that drives patients' expectations is the motivation to achieve spectacle independence consistent with changing lifestyle patterns and professional needs. Thus, the demand for MIOLs is expected to surge globally due to the large number of cataract surgeries (~26 million cataract surgeries performed in 2017); changing socioeconomic frameworks; improvements in healthcare sectors and expenditure; access to innovative, advanced IOLs; and due to the increased awareness.[8]

FineVision Micro F (PhysIOL, Liege, Belgium) and the AT LISA tri 839MP (Carl Zeiss Meditec AG, Jena, Germany) are the first trifocal IOLs that were introduced in the market in 2010 and 2012, respectively. The EDOF IOL TECNIS Symfony (Abbott Medical Optics, Santa Ana, CA) was launched in 2014. The AcrySof IQ PanOptix Model TFNT00 (Alcon Laboratories, Fort Worth, TX) is a presbyopia-correcting IOL first launched in Europe in 2015, that uses the ENhanced LIGHT ENergy (ENLIGHTEN; Alcon Laboratories, Fort Worth, TX) optical technology.

This article provides an overview of the optical characteristics and clinical performance of the AcrySof IQ PanOptix and discusses it in the context of the FineVision, AT LISA trifocal IOLs and the Symfony EDOF IOL.

LITERATURE SEARCH METHODOLOGY

A literature search was performed for PanOptix, each of the trifocal IOLs and EDOF IOL in the MEDLINE/PubMed database (cutoff date: August 10, 2018), to identify studies reporting visual performance in patients after implantation. Only English language articles were screened for relevance. In addition, we also performed a manual search for potential trials that might have been missed in the primary searches. The following key terms were used:

For PanOptix: PanOptix[All Fields] AND ("lenses, intraocular"[MeSH Terms]) OR ("lenses"[All Fields] AND "intraocular"[All Fields]) OR "intraocular lenses"[All Fields] OR ("intraocular"[All Fields] AND "lens"[All Fields]) OR ("intraocular lens"[All Fields]).

For Fine Vision: FineVision[All Fields] AND trifocal[All Fields]. *For At LISA tri 839MP*: AT LISA[All Fields] AND (trifocal[All Fields] AND IOL[All Fields]). *For Symfony*: [(extended depth focus) OR extended vision] AND Symfony; (extended depth of focus) AND Symfony; (extended range of vision) AND Symfony.

ACRYSOF IQ PANOPTIX IOL MODEL TFNT00

The PanOptix Model TFNT00 (henceforth referred as PanOptix) is an ultraviolet (UV) and blue light filtering, non-apodized, foldable presbyopia-correcting IOL. This single-piece IOL has a central biconvex optic, with an inner diffractive and an outer refractive zone, and is made of a hydrophobic material acrylate/methacrylate copolymer and has 2 open-loop haptics.[9,10]

The lens is 13.0 mm in diameter with a central optic of 6.0 mm and is available in a diopter (D) range of +6.0 to +30.0 D (0.5 D increments) and +31.0 D to +34.0 D (1.0 D increments). The posterior lens surface is spherical, and the anterior surface is aspheric with a diffractive surface on the central 4.5 mm portion of the optic zone, and divides the incoming light to create an intermediate addition power of +2.17 D (60 cm) and a +3.25 D (40 cm) near add power (Table 1). The anterior surface is designed with negative spherical aberration to compensate for the positive spherical aberration of the average human cornea.

The PanOptix IOL is based on a quadrifocal (4 foci) design and uses a proprietary optical technology, ENLIGHTEN, to redistribute the focal point at 120 cm to the distance focal point for amplified performance. This results in 2-step heights that is equal to 2 add powers/2 focal points (plus distance from base curve; Fig. 1). Light is split to 3 foci (distance: ∞, intermediate at 60 cm, and near at 40 cm). The 4.5 mm non-apodized, diffractive zone allows high light utilization, transmitting 88% of light to the retina at a 3.0 mm pupil size, and provides optimized performance in a wide range of lighting conditions due to low dependence on the pupil size.[9,10] This light energy is distributed 25% each for near and intermediate and 50% for distance vision.

FINEVISION MICRO F

The FineVision Micro F (henceforth referred as FineVision) is the first trifocal IOL that received the CE mark in 2010. It is a single-piece, 25% hydrophilic acrylic, UV and blue light filtering, fully diffractive trifocal IOL with an intended addition power of +1.75 D for intermediate vision and a maximum addition power of +3.5 D for near vision (Table 1), offering an intermediate and reading distance of ~80 cm and ~40 cm, respectively.[11] The IOL creates trifocality by combining 2 diffractive profiles.[12] In total, 86% of light energy is transmitted to the retina. The apodized IOL optic is designed to allocate 49% of the light energy to distance vision, 34% to near vision, and 17% to intermediate vision, at a 3.0 mm pupil aperture.[12]

TABLE 1. Optical Features of the Trifocal and Extended Depth of Focus IOLs Discussed in the Current Article

IOL Characteristics	AcrySof IQ PanOptix	FineVision Micro F	AT LISA tri 839MP	TECNIS Symfony
Optical design	Diffractive-refractive hybrid	Diffractive	Diffractive	Diffractive
Optic type	Non-apodized	Apodized	Non-apodized	Non-apodized
Addition (near/intermediate)	+3.25 D/+2.17 D	+3.50 D/+1.75 D	+3.33 D/+1.66 D	−/+1.75 D
IOL size	13.0 mm	10.75 mm	11.0 mm	13.0 mm
Optic size	6.0 mm	6.15 mm	6.0 mm	6.0 mm
Diffractive zone	4.5 mm	6.0 mm	6.0 mm	~4.9 mm
Optic material	Hydrophobic acrylate/ methacrylate copolymer	25% hydrophilic acrylate	25% Hydrophilic acrylate with hydrophobic surface properties	Hydrophobic acrylate
Spherical aberration	−0.10 μm	−0.11 μm	−0.18 μm	−0.27 μm
Refractive index	1.55	1.46	1.46	1.47
Range	6.0 to +34.0 D	+10.0 to +35.0 D	0.0 to +32.0 D	+5.0 to +34.0 D
Pupil dependence	Independent	Dependent	Independent	Independent
Toric availability*	Yes	Yes	Yes	Yes

D indicates diopter; IOL, intraocular lens; UV, ultraviolet.

*All the 4 IOLs discussed also have toric model options available (AcrySof IQ PanOptix Toric IOL, FineVision Toric Pod FT, AT LISA tri toric 939MP, Symfony Toric lenses ZXT series) to correct for astigmatism. The toric IOLs are beyond the scope of the current article and hence not discussed.

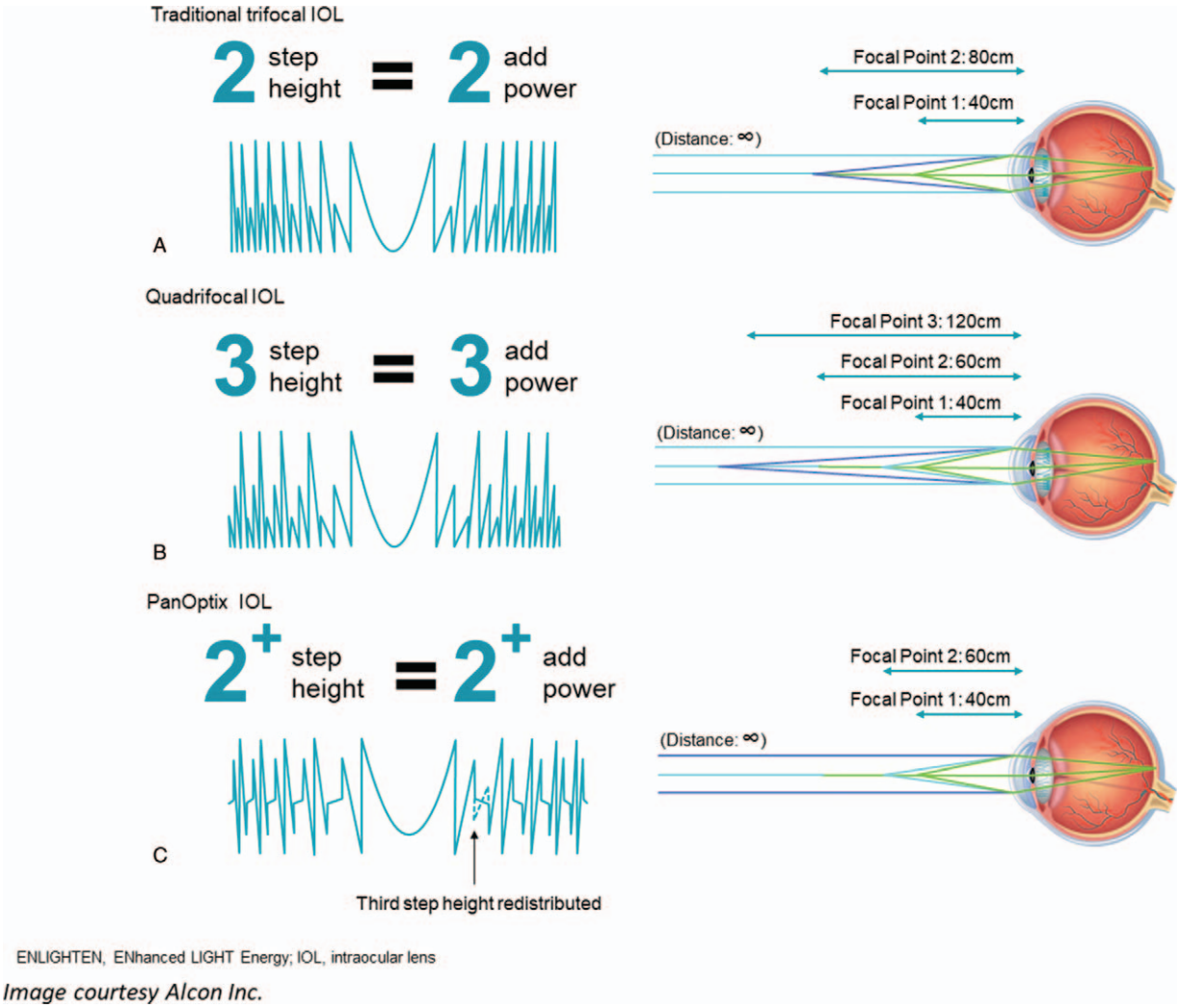

FIGURE 1. The difference between a traditional trifocal IOL and PanOptix IOL. A, Traditional IOLs have 2 added powers with an intermediate focal point at 80 cm. B, Quadrifocal IOLs have 3 added powers; this provides more continuous vision but may compromise distant contrast. C, The ENLIGHTEN optical technology used in PanOptix redirects light from the third step height (120 cm) to distance for amplified performance. IOL indicates intraocular lens.

Another trifocal aspheric, diffractive IOL, FineVision HP (PhysIOL) is also available. This trifocal IOL is similar to the FineVision IOL but is made of hydrophobic material. It is a 1-piece, glistening-free lens available in the range of +10.0 to +35.0 D (0.5 D increments). This IOL was launched in 2017.[13]

AT LISA TRI 839MP

The AT LISA tri 839MP (henceforth referred as AT LISA) is a single-piece, UV filtering, diffractive trifocal IOL with +3.33 D near addition and +1.66 D intermediate addition, offering a reading and intermediate distance of ~40 and ~80 cm, respectively (Table 1).[14] It is composed of a hydrophilic-acrylic (25% water content) material with hydrophobic surface properties. Only the central area of 4.34-mm diameter functions like a trifocal, whereas the peripheral area is a bifocal optic. Across all pupil sizes, 85.7% of light energy is transmitted to the retina. The IOL has asymmetrical light distribution across 3 foci: 50% to distance, 20% to intermediate, and 30% to near vision.[14] The lens received the CE mark in 2012.

TECNIS SYMFONY MODEL ZXR00

The Symfony ZXR00 lens (henceforth referred as Symfony) is a single-piece, biconvex, UV blocking hydrophobic-acrylic EDOF IOL with +1.75 D intermediate addition. This IOL has an achromatic diffractive surface that provides a low add foci which results in elongating the range of vision from distance through intermediate.

The achromatic surface aims to correct chromatic aberrations of the cornea. This lens has an overall diameter of 13.0 mm with an optic of 6.0 mm (Table 1). The lens received a CE mark in Europe in June 2014 and is the first EDOF-labeled IOL approved in the United States in 2016.[15]

LITERATURE SEARCH RESULTS

For PanOptix the search identified 15 studies. Two optical bench performance studies were omitted as 1 was in German, and the other compared PanOptix versus a bifocal IOL. In all, 12 studies that evaluated the visual outcomes in patients who underwent bilateral implantation with PanOptix IOL were included (Table 2).[10,16–26] However, the study comparing PanOptix with a

TABLE 2. Visual Outcomes Reported in Patients After Bilateral Implantation With PanOptix Trifocal IOL in Clinical Studies

Author	Study Design (Follow-Up Period)	Surgery	IOL	Patient (Eyes)	UDVA (logMAR)	CDVA (logMAR)	UIVA (logMAR)	CIVA (logMAR)	UNVA (logMAR)	CNVA (logMAR)
Escandón-García et al (2018)[24]	Prospective (39–50 d)	Cataract	PanOptix Symfony Fine Vision	45 (90)	0.07 ± 0.10 0.08 ± 0.10 0.08 ± 0.09	−0.07 ± 0.19 −0.10 ± 0.19 −0.24 ± 0.14	—	—	—	—
Mencucci et al† (2018)[23]	Nonrandomized, prospective (3 mo)	Cataract	PanOptix AT LISA tri Symfony	60 (120)	−0.02 ± 0.08 0.00 ± 0.02 −0.04 ± 0.05	−0.03 ± 0.08 −0.01 ± 0.02 −0.05 ± 0.05	**At 60 cm** 0.07 ± 0.04* (PanOptix) **At 80 cm** 0.16 ± 0.06 0.11 ± 0.07* 0.07 ± 0.07*	**At 60 cm** 0.06 ± 0.05* (PanOptix) **At 80 cm** 0.14 ± 0.08 0.10 ± 0.06* 0.06 ± 0.07*	0.15 ± 0.05* 0.18 ± 0.05* 0.25 ± 0.08	0.12 ± 0.04* 0.13 ± 0.04* 0.20 ± 0.1
Alió et al (2018)[26]	Prospective, consecutive case series (6 mo)	Cataract	PanOptix	26 (52)	0.07 ± 0.10	0.01 ± 0.04	0.12 ± 0.13	0.12 ± 0.12	0.16 ± 0.09	0.08 ± 0.06
Ruiz-Mesa et al (2018)[21]	Dual-arm, comparative, noninterventional (9–24 mo)	Cataract or RLE	PanOptix Symfony	34 (68)	0.0 ± 0.03 0.05 ± 0.12	−0.03 ± 0.03 −0.02 ± 0.03	—	**At 60 cm** 0.06 ± 0.10 0.05 ± 0.04 **At 80 cm** 0.06 ± 0.06 0.06 ± 0.04	—	0.04 ± 0.06* 0.20 ± 0.06
Cochener et al ‡ (2018)[25]	Prospective, randomized, comparative (6 mo)	Cataract	PanOptix Fine Vision Symfony	60 (120)	0.976 ± 0.139 0.961 ± 0.100 0.979 ± 0.06	—	—	—	0.66 ± 0.00* 0.64 ± 0.07* 0.57 ± 0.15	
de Medeiros et al (2017)[18]	Prospective, nonrandomized, comparative (180 d)	Cataract	PanOptix Mixed EDOF (Symfony + Tecnis ZMB00)	20 (40)	0.01 ± 0.04 −0.01 ± 0.15*	0.07 ± 0.06* −0.16 ± 0.11	0.14 ± 0.05* 0.20 ± 0.05	—	−0.03 ± 0.04* 0.11 ± 0.07	—
Kohnen et al (2017)[10]	Prospective, single-arm (3 mo)	Cataract	PanOptix	27 (54)	0.00 ± 0.094	−0.07 ± 0.076	**At 60 cm** 0.00 ± 0.111 **At 80 cm** 0.09 ± 0.107	**At 60 cm** 0.01 ± 0.124 **At 80 cm** 0.10 ± 0.126	0.01 ± 0.087	0.03 ± 0.113
Monaco et al§ (2017)[22]	Prospective randomized, double-blind, controlled (4 mo)	Cataract	PanOptix Symfony Acrysof SN60WF	60 (120)	0.00 ± 0.04 0.03 ± 0.05 0.02 ± 0.06	−0.01 ± 0.01 −0.01 ± 0.02 −0.01 ± 0.02	0.23 ± 0.07* 0.27 ± 0.08 0.42 ± 0.09	0.13 ± 0.07* 0.16 ± 0.07* 0.29 ± 0.11	0.02 ± 0.06* 0.07 ± 0.08* 0.38 ± 0.10	0.01 ± 0.04* 0.07 ± 0.07* 0.32 ± 0.09
Gundersen and Potvin (2017)[16]	Double-arm comparative noninterventional (6–24 mo)	Cataract	PanOptix Fine Vision	60 (120)	−0.05 ± 0.07 −0.04 ± 0.07	—	—	—	0.07 ± 0.07* 0.11 ± 0.08	—
García-Pérez et al (2017)[19]	Prospective case series (1 mo)	Cataract	PanOptix	58 (116)	0.03 ± 0.046	—	0.12 ± 0.143	—	**At 33 cm** 0.02 ± 0.099	—
Lawless et al (2017)[17]	Retrospective consecutive case series (4–9 wk)	Cataract or RLE	PanOptix	33 (66)	0.01 ± 0.10	—	0.30 ± 0.14	—	0.11 ± 0.04	—
Vilar et al (2017)[20]	Prospective, nonrandomized, comparative (1 mo)	Cataract	PanOptix Blended bifocal (Restor SV25T0 + SN6AD1)	20 (40)	0.01 ± 0.04* 0.08 ± 0.05	0.01 ± 0.06 0.04 ± 0.06	0.14 ± 0.05* 0.22 ± 0.06	—	−0.03 ± 0.04* 0.07 ± 0.03	—

Search term in Medline/Pubmed: (PanOptix AND intraocular lens)—In all, 15 articles were obtained. A manual search was also performed. Following screening (non-English, optical bench/in vitro studies; studies not reporting VA outcomes and those for toric IOL were excluded) and removing duplicates, 12 studies were included. CDVA indicates corrected distance visual acuity; CIVA, distant corrected intermediate visual acuity; CNVA, distant corrected near visual acuity; DOF, extended depth of focus lens; IOL, intraocular lens; logMAR, logarithm of minimum angle of resolution; RLE, refractive lens exchange; SD, standard deviation; UDVA, uncorrected distance visual acuity; UIVA, uncorrected intermediate visual acuity; UNVA, uncorrected near visual acuity; VA, visual acuity.

*$P < 0.05$ vs comparator; VA is reported in mean ± SD. Unless specified the reported measurements are of binocular uncorrected and corrected distance visual acuity at 4 m (UDVA, CDVA) and uncorrected and corrected intermediate (60 cm), and uncorrected and corrected near (at 40 cm) VA.

†Ref Mennuci et al (2018); AT LISA was significantly better than Symfony and PanOptix at 80 cm; Symfony was significantly better than PanOptix at 80 cm; AT LISA and PanOptix were significantly better than Symfony for near vision ($P < 0.05$); no significant difference with AT LISA and PanOptix for near vision.

‡Decimal value reported.

§Ref Monaco et al (2017); PanOptix was significantly better than Symfony and monofocal IOL ($P \leq 0.05$); Symfony was significantly better than monofocal IOL ($P < 0.05$).

bifocal IOL is not discussed in the article.[20] In addition, results of a PanOptix study that were presented at the ESCRS 2018 conference are also briefly discussed (not part of the literature search).[27]

Similarly, after screening, 14, 16, and 9 studies were identified for FineVision, AT LISA, and Symfony, respectively. A summary of key studies and clinical outcomes for these IOLs is provided in Tables 3 to 5, respectively.[15,28–65]

OPTICAL BENCH CHARACTERISTICS OF PANOPTIX

This section discusses the optical dynamics of PanOptix, trifocal, and the EDOF IOLs in an in vitro analysis. The clinical experience of patients with these IOLs is discussed separately.

Carson D et al (2016)[66] compared the optical bench performance for PanOptix, FineVision, and AT LISA. Contrast sensitivity (CS) was evaluated with modulation transfer function (MTF) measurements in a spherical aberration matching cornea for 3.0 mm of aperture for 2 spatial frequencies: 50 line pairs per millimeter (lp/mm) and 100 lp/mm, equivalent to 20/40 and 20/20 Snellen visual acuity (VA), respectively. For PanOptix and each trifocal IOL, the MTF curve showed 3 mean peaks corresponding to distance, intermediate, and near foci. PanOptix had higher MTF values at both distance and intermediate foci than the other 2 trifocals, whereas the near focus values were highest for AT LISA.[66] The image quality performance of PanOptix was comparable to AT LISA and FineVision IOLs at distance and near foci, but the image contrast at intermediate 60 cm focus was significantly better for PanOptix compared with both AT LISA and FineVision. This was expected because, by design, the intermediate focal point for both FineVision and AT LISA is around 80 cm. The badal images of the Early Treatment Diabetic Retinopathy Study chart also showed that PanOptix has a better image resolution at 60 cm than the 2 trifocal IOLs while providing a similar resolution at 80 cm. The 20/40 text line was resolvable with PanOptix from 80 cm to 40 cm. The best near focal point was 42 cm for PanOptix and 40 cm for the FineVision and AT LISA IOLs. The bench-measured intensity of background halos was relatively higher for AT LISA than the other 2 lOLs.[66] Overall, these bench results demonstrated that PanOptix is equivalent to or shows a better optical performance than the trifocal IOLs for image quality, resolution, and photic phenomena.

An optical bench comparison for PanOptix and Symfony is not available in the literature. An in vitro optic bench comparison of the optical quality of the EDOF Symfony IOL with AT LISA and FineVision has been reported.[67] Unlike trifocal IOLs, the MTF curve for Symfony showed only 2 peaks corresponding to intermediate and distant vision, consistent with bifocal design. Both the trifocal IOLs showed better optical quality at distance and near vision, whereas Symfony had better performance at the intermediate range (highest MTF at −2.00 D and −2.50 D). All lenses showed comparable MTFs at −1.50 D and −3.00 D. Furthermore, the energy distribution was asymmetrical for both trifocal IOLs and more pronounced for FineVision than AT LISA; Symfony showed a symmetrical energy distribution.[67]

CLINICAL OUTCOMES WITH PANOPTIX

Noncomparative Studies

Kohnen et al (2017)[10] reported good visual performance of PanOptix at a range of distances (4 m, 80 cm, 60 cm, and 40 cm), in particular at intermediate VA (logMAR >0.1), with the best VA at 60 cm, in a 3-month prospective study (n = 27). In total, 87% and 96% of eyes achieved a monocular uncorrected distant VA (UDVA) of ≤0.10 logMAR and ≤0.2 logMAR, respectively. Similarly, 85% and 91% of eyes achieved monocular uncorrected near VA (UNVA) of ≤0.10 logMAR and ≤0.2 logMAR, respectively; 50% achieved a UNVA of at least 0.0 logMAR. In all, 83% and 94% of eyes demonstrated an uncorrected intermediate VA (UIVA) of at least 0.2 logMAR at 80 cm and at 60 cm, respectively. The best VA was obtained at 0.00 D (4 m) and −2.00 D (50 cm) in both monocular (−0.05 logMAR and 0.01 logMAR) and binocular (−0.07 logMAR and −0.02 logMAR) defocus curves. The mean CS (measured using the Frankfurt-Freiburg Contrast and Acuity Test System) in photopic, mesopic, and mesopic-with-glare lighting conditions was 1.55 ± 0.35, 0.91 ± 0.26, and 0.86 ± 0.26 $\log CS_{Weber,}$ respectively.[10]

This study used a short quality of vision (QoV) questionnaire (19 items) to assess patient-reported outcomes based on presence of visual disturbances and lifestyle activities, choice of IOL, and spectacle independence. Complete spectacle independence was achieved by 96% of patients with only 1 patient (1/27) reporting the use of spectacles for far distance. In all, 93% of patients reported experiencing an optical phenomena (89% halos, 11% glare, 7% double vision, 4% each ghosting and distorted vision).[10] Although the reported incidence for far distance halos was high, patients reported that it was not bothersome. In all, 81% of patients responded that they would choose the same IOL again and would recommend it to others. For daily life activities, patients rated (score range: 1 = good to 6 = bad) a good mean score for the quality of uncorrected vision of 2.1 ± 0.54 for distance activities (car driving, TV, theatre, among others), and of 1.8 ± 0.10 for near and intermediate distance (cooking, computer, musical instrument, newspaper).[10]

Lawless et al (2017),[17] in a retrospective case series study (n = 33), reported excellent unaided vision at all distances with PanOptix (Table 2). An uncorrected VA of 20/40 Snellen equivalent or better was achieved by all patients for distance and near positions and by 88.9% of patients for the intermediate position.[17] In all, 78.8% of patients achieved UDVA of 0.01 ± 0.10 logMAR (~20/20 Snellen equivalent UDVA or better) and 85.2% achieved a mean UNVA of 0.11 ± 0.04 logMAR. Halos of moderate severity were reported by 15% of patients in the early postoperative period but it did not impair their activities, and the complaints diminished by the subsequent postoperative visits (between 4 weeks and 3 months).[17]

Garcia-Perez et al (2017)[19] reported excellent visual outcomes in patients (n = 58) implanted with PanOptix during the 1-month follow-up (Table 2). Monocular and binocular VA was measured at 33 cm (for near) and at 60 cm (for intermediate). No significant differences in distance, intermediate, or near VA and distance CS ($P > 0.05$ for all spatial frequencies measured using the functional acuity contrast test [Test SV-1000] of the CC-100 (HW 5.0 Series system) in mesopic and photopic conditions were noted, supporting the fact that the visual performance of PanOptix is consistent across different levels of illumination. All patients

TABLE 3. A Summary of Uncorrected Visual Acuity Outcomes and Performance Reported for the FineVision Micro F Trifocal IOL, in Clinical Studies

First Author	Study Design (Follow-Up Period)	Surgery	IOL	Patient (Eyes)	UDVA (logMAR)	UIVA (logMAR)	UNVA (logMAR)	Other Key Findings
Bilbao-Calabuig et al (2017)[41]	Retrospective, nonrandomized (3 mo)	Cataract	FineVision AT LISA	5042 (10,084)	0.01 ± 0.05 -0.01 ± 0.06*	−0.05 ± 0.12 −0.05 ± 0.14	0.05 ± 0.08 0.05 ± 0.08	Spectacle independence: >98% in both groups for distance and intermediate vision; 92% in AT LISA and 95% in Fine Vision ($P < 0.001$) had Spectacle independence for near vision; 98% of patients were "satisfied" to " very satisfied"
Ferreira-Ríos et al† (2018)[38]	Prospective, case series (6 mo)	Cataract	FineVision	15 (30)	**At 6 m** 0.06 ± 0.11	**At 70 cm** 0.04 ± 0.08 **At 60 cm** 0.13 ± 0.08 **At 50 cm** 0.12 ± 0.06	**At 40 cm** 0.05 ± 0.08 **At 30 cm** 0.03 ± 0.04	Spectacle independence 86.6%; overall patient satisfaction was excellent
Martinez-de-la-Casa et al‡ (2016)[34]	Case series (3 months)	Cataract	FineVision AT LISA	50 (100)	0.05 ± 0.06 −0.04 ± 0.11	0.25 ± 0.10 0.32 ± 0.09	0.13 ± 0.10 0.12 ± 0.11	No differences in CS between 2 IOL groups
Plaza-Puche et al§ (2016)[33]	Prospective, nonrandomized (3 mo)	Cataract	FineVision AT LISA ReSTOR D1	(90)	0.08 ± 0.14 −0.10 ± 0.10* 0.04 ± 0.15	-	0.22 ± 0.11 0.14 ± 0.20 0.20 ± 0.20	No significant differences observed in low mesopic CS function between trifocals and other MIOLs
Cochener (2016)[40]	Prospective, randomized (6 mo)	Cataract	FineVision Tecnis ZMB00	27 (54)	0.02 ± 0.04 0.04 ± 0.05	**At 66 cm** 0.07 ± 0.05 0.11 ± 0.05	**At 33 cm** 0.01 ± 0.00 0.01 ± 0.00	No significant differences in CS function between the trifocal and bifocal IOL; spectacle independence achieved by 100% (FineVision) and 92% (Tecnis) of patients; 58% (FineVision) and 75% (Tecnis) of patients reported discomfort in night vision; patient satisfaction was 92%−93% in the 2 groups
Jonker et al (2015)[37]	Prospective, randomized (6 mo)	Cataract	FineVision ReSTOR +3.0D (Bifocal)	28 (56)	−0.01 ± 0.11 0.00 ± 0.09	**At 70 cm** 0.32 ± 0.15 0.28 ± 0.08	0.15 ± 0.13 0.12 ± 0.08	80% complete spectacle independence with FineVision vs 50% in the bifocal group. No significant differences in refractive outcomes, reading speed, or patient satisfaction were observed
Marques and Ferreira (2015)[36]	Prospective, comparative (3 mo)	Cataract	FineVision AT LISA	30 (60)	0.02 ± 0.02 0.00 ± 0.01	0.03 ± 0.05 0.13 ± 0.42	0.02 ± 0.02 0.13 ± 0.05	At all the spatial frequencies tested, the binocular CS was similar between the 2 IOLs. Complete spectacle independence achieved in both groups. No significant difference observed in dysphotopic scores of the 2 IOLs
Marques et al (2015)[35]	Prospective, case series (12 mo)	Cataract	FineVision	10 (20)	−0.10 ± 0.05	**At 70 cm** 0.00 ± 0.03	0.20 ± 0.11	No significant IOL decentration or PCO was observed; halos and glare were reported by 3 people during night driving in the first postoperative month but had no impact on daily activities and, it improved during the course of follow-up
Carballo-Alvarez et al‡ (2015)[28]	Prospective, case series (12 mo)	Cataract	FineVision	22 (44)	−0.05 ± 0.05	0.15 ± 0.10	0.06 ± 0.10	The improvement in intermediate vision observed with trifocal IOL did not impair distance and near VA. Binocular CS significantly improved after surgery
Cochener et al (2014)[39]	Prospective (6 mo)	Cataract	FineVision	99 (198)	0.01 ± 0.07	0.06 ± 0.08	0.00 ± 0.03	31% of patients reported some symptoms of glare (40% reported ghost images, 49% reported halos, and 80% reported problems with night driving). Postoperatively, spectacles were required by: 4% of patients for distance and intermediate vision, 20% to read small characters, and 7% to read the newspaper
Alio et al† (2013)[30]	Prospective, noncomparative (6 mo)	Cataract	FineVision	20 (40)	0.18 ± 0.13	**At 80 cm** 0.20 ± 0.11	0.26 ± 0.15	No intraoperative complications or PCO cases were reported; only 1 patient reported halos
Vryghem and Heireman (2013)[31]	Prospective, consecutive (6 mo)	Cataract or RLE	FineVision	25 (50)	−0.04 ± 0.09	**At 70 cm** −0.10 ± 0.15	**At 35 cm** 0.02 ± 0.06	CS did not decrease upon dim conditions, 68% of patients did not complain of halos, 100% (distance) and 80% (near) spectacle independence
Sheppard et al† (2013)[32]	Prospective, nonrandomized (2 mo)	Cataract	FineVision	15 (30)	0.19 ± 0.09	—	—	Binocular CS was better than monocular values. No patient reported adverse photic phenomena. NAVQ scores for subjective satisfaction with near vision were high
Cochener et al (2012)[29]	Prospective (6 mo)	Cataract	FineVision	47 (94)	0.02 ± 0.09	0.05 ± 0.08	0.00 ± 0.04	No patient reported seeing ghost images

Search term in Medline/Pubmed: (trifocal) AND FineVision Micro F; [(trifocal) AND FineVision]. In total, 43 articles were obtained and a manual search was also performed. After screening (non-English, optical bench/ in vitro studies; studies not reporting VA outcomes and FineVision toric IOL articles were excluded) and removing duplicates, 14 studies were included. VA is reported in mean ± SD. Unless specified the reported measurements are of binocular uncorrected intermediate (80 cm), and uncorrected near (at 40 cm) visual acuity. CS indicates contrast sensitivity; IOL, intraocular lens; logMAR, logarithm of the minimal angle of resolution; NAVQ, near activity visual questionnaire; PCO, posterior capsular opacification; RLE, refractive lens exchange; SD, standard deviation; UDVA, uncorrected distance visual acuity; UIVA, uncorrected intermediate visual acuity; UNVA, uncorrected near visual acuity; VA, visual acuity.

*$P < 0.05$ vs comparator.

†Monocular VA reported.

‡Distance corrected VA reported.

§This study included 6 IOLs.

achieved a binocular uncorrected VA better than 0.3 logMAR (20/40 Snellen equivalent) for distance and near vision, and 94.8% of patients did so for intermediate vision. The monocular defocus curves showed that VA better than 0.2 logMAR was maintained between −2.50 and +0.50 D. Overall, 94.8% of patients in this study achieved complete spectacle independence; 3 (5.1%) patients reported using spectacles for some activities.[19]

The study used the Catquest 9-SF questionnaire to evaluate patient satisfaction. A high level of satisfaction was observed: 84.5% patients reported no difficulties and 15.5% reported some difficulties related to vision in their daily lives; >79% of patients reported having no difficulties in performing all tasks. Driving at night was the most challenging activity with 25.9% of patients citing difficulty as occasional or often; 32.8% reported seeing halos often or always with low illumination and 10.3% reported glare. One case of posterior capsule opacification (PCO) was reported and was scheduled for neodymium-doped yttrium aluminum garnet (Nd:YAG) capsulotomy.[19]

Alio et al (2018),[26] in a 6-month prospective case series (n = 26, 52 eyes), reported significant improvement in uncorrected and corrected VA outcomes at 1 month after PanOptix implantation, and the VA remained stable through the 6-month follow-up. The monocular defocus curves showed that a VA better than 0.3 logMAR was maintained between +0.50 D and −3.00 D. The CS (assessed by Pelli-Robson) at 3 months after surgery was 1.58 ± 0.18 (monocular) and 1.86 ± 0.15 (binocular) Log Units. CS values obtained in this study were similar to normal values for phakic patients with the same age sample and pseudophakic patients with monofocal or multifocal IOL implantation.[26] Postoperative light distortion indices (ie, the measure of the size and shape of the light distortion surrounding a central source of light as visualized by the patient, and is an indicator of visual quality) reduced significantly in binocular conditions.

Consistent with reported visual outcomes, the mean Rasch scores (evaluated using the near visual satisfaction questionnaire; 0 = completely satisfied; 100 = completely unsatisfied) for subjective satisfaction with near vision showed a significant improvement (preoperative 67.18 ± 20.64 vs 20.21 ± 9.20 at month 3; $P < 0.01$). The overall satisfaction scores (0 = completely satisfied; 3 = completely unsatisfied) for near vision also improved at month 3 (preoperative 3.50 ± 0.80 vs 1.06 ± 1.06 at month 3; $P = 0.03$).[26]

Comparative Studies

PanOptix Versus FineVision IOL

One study compared the refractive outcomes with PanOptix versus the FineVision IOL.[16] Two additional studies compared PanOptix, FineVision, and the Symfony IOLs, and the outcomes in these studies are discussed under Symfony IOL.[24,25]

Gundersen and Potvin (2017)[16] compared the VA, low contrast VA and QoV of PanOptix (n = 30) with FineVision (n = 30) in a 6-month follow-up study. The study reported significantly better intermediate VA at 60 cm with PanOptix ($P = 0.01$); no significant differences were observed at other distances.[16] The binocular defocus curves of the 2 trifocals showed a significant difference at 3 defocus levels: the FineVision IOL demonstrated a better performance at −1.0 D ($P = 0.02$), a defocus corresponding to viewing at 80 cm; PanOptix demonstrated better performance at −1.5 D and −2.00 D ($P < 0.01$ for both), which is at a viewing distance of ∼60 to 45 cm. For both IOLs, the preferred reading distance between 42 and 43 cm and PanOptix demonstrated a better VA at the preferred reading distance ($P = 0.04$). Both groups had a mean low contrast VA between 0.3 and 0.4 logMAR. In this study, some patients (n = 11/30) in the FineVision group had bilateral implantation with the toric IOL and 2 other patients received the toric version in one eye.[16]

On all parameters for visual disturbances, frequency, severity, and degree of bothersomeness, the QoV questionnaire mean Rasch scores were lower (ie, better performance) for PanOptix than for FineVision, even though there was no statistically significant difference between the 2 groups. Halos (mild to moderate) were the most frequently reported phenomenon with an incidence of 60% in each group. However, only 3 patients with FineVision and 1 with PanOptix reported the halos to be a little bothersome, whereas others did not find it to have any impact on QoL.[16]

PanOptix Versus AT LISA IOL

One randomized, double-masked, prospective and multicenter study compared the performance of PanOptix (n = 93) with the AT LISA IOL (n = 89).[27] The PanOptix group achieved significantly better binocular UIVA at 60 cm ($P < 0.002$) and binocular UNVA at 40 cm ($P < 0.003$) versus AT LISA. On the defocus curve, the PanOptix group achieved a mean VA of 20/25 or better from +0.50 D to −2.50 D and higher (ie, better) mean VA between −1.50 D and −2.50 D versus AT LISA. Both IOL groups demonstrated similar CS in photopic or mesopic conditions with and without glare. Patient satisfaction was >95% in both groups at the 6 months' visit. Mild halos and glare were reported by a few patients in both groups within 1 to 2 weeks of implantation; these resolved without intervention.[27]

PanOptix Versus Symfony IOL

Six studies have compared the optical performance of PanOptix with Symfony; 4 studies had an additional comparator IOL group (Table 2).[18,21–25,64] Consistent with their optical design and properties, the defocus curves of PanOptix and Symfony showed a distinctly different pattern of vergence. Overall, PanOptix demonstrated significantly better near (at 40 cm) vision than Symfony.

de Medeiros et al (2017)[18] compared the visual outcomes and CS between PanOptix (n = 10) and blended implantation of Symfony in the dominant eye and Tecnis ZMB00 in the nondominant eye (mixed EDOF group, n = 10) and reported significantly better visual outcomes at 40 cm (UNVA) and 60 cm (UIVA) with PanOptix (Table 2). The distance vision was found to be significantly better in the blended group than PanOptix (−0.096 vs 0.010 logMAR, $P = 0.0295$; Table 2). The defocus curve showed a difference in almost all of the defocus levels assessed between the lenses ($P < 0.001$). The mixed EDOF group showed peaks close to −3.0 D and −1.50 D with an average VA of −0.03 and −0.05 logMAR, respectively. PanOptix demonstrated a significantly better near vision at the defocus levels −2.00 D and 0.0 D with a VA of −0.02 and −0.07 logMAR, respectively, and showed a continuous range near vision of 0.0 logMAR from −2.50 to −1.50 D. The CS (measured using the CSV-1000 chart) was better at low spatial frequencies (3 and 6 cpd) in the blended EDOF group under photopic conditions without glare ($P < 0.01$); no statistically significant difference in CS was observed between

TABLE 4. A Summary of Uncorrected Visual Acuity Outcomes and Performance Reported for the AT LISA Tri 839MP Trifocal IOL, in Clinical Studies

Author	Study Design (Follow-Up Period)	Surgery	IOL	Patient (Eyes)	UDVA (logMAR)	UIVA (logMAR)	UNVA (logMAR)	Other Key Findings
Yang et al (2018)[56]	Prospective, (3 mo)	Cataract	AT LISA	26 (30)	0.05 ± 0.10	0.23 ± 0.12	0.21 ± 0.15	High levels of patient satisfaction and 100% spectacle independence; none of the patients reported glare or halos
Steinwender et al † (2018)[55]	Retrospective, case series (3 mo)	Cataract	AT LISA (myopic) AT LISA (control)	19 (36)	0.06 ± 0.08 −0.01 ± 0.10	0.13 ± 0.09 0.04 ± 0.10	0.12 ± 0.07 0.04 ± 0.11	Satisfactory VA outcomes at various distances achieved in highly myopic eyes with low IOL power; excellent VA achieved in eyes with high dioptric power
Liu et al (2018)[49]	Prospective, nonrandomized (3 mo)	Cataract	AT LISA AT LISA 809M	55 (110)	0.02 ± 0.09 0.04 ± 0.10	0.08 ± 0.10 0.26 ± 0.13*	0.11 ± 0.11 0.15 ± 0.11	Halos reported in 84% and 86.7%, and glare by 40% and 33.3% in the trifocal and bifocal group respectively. Complete spectacle independence: 88% in trifocal vs 80% in bifocal. High patient satisfaction 90%–92% was reported in both IOL groups
Kim et al (2018)[45]	Retrospective, (1 mo)	Cataract or RLE	AT LISA AT LISA 801M	23 (46)	0.06 ± 0.11 0.06 ± 0.11	0.22 ± 0.10* 0.35 ± 0.10	0.05 ± 0.09 0.04 ± 0.11	No significant differences were found in reading speed between the 2 IOLs at any letter sizes
Mencucci et al (2017)[50]	Prospective, (3 mo)	Cataract	AT LISA	21 (42)	0.00 ± 0.05	0.11 ± 0.07	0.18 ± 0.05	Patient satisfaction was very high, spectacle independence was 100% for far and intermediate distances; ∼71.4% of patients required glasses "sometimes" for near vision
Kaymak et al (2017)[44]	Prospective, comparative (12 mo)	Cataract	AT LISA AT LISA 801M Restore D1	52 (104)	−0.02 ± 0.08 −0.01 ± 0.06 −0.01 ± 0.06	**At 70 cm** 0.12 ± 0.12* 0.25 ± 0.20 0.15 ± 0.20 **At 80 cm** 0.10 ± 0.11 0.20 ± 0.20 0.17 ± 0.20 **At 90 cm** 0.07 ± 0.11 0.19 ± 0.21 0.19 ± 0.15	0.13 ± 0.12 0.12 ± 0.12 0.10 ± 0.12	Reading acuity at preferred distance was comparable between the trifocal and bifocal IOLs
Alio et al (2018)[43]	Prospective, randomized (6 -mo)	Cataract	AT LISA AT LISA 809M Restore D1	52 (104)	−0.03 ± 0.07 0.04 ± 0.21 0.01 ± 0.10	**At 70 cm** 0.14 ± 0.16 0.24 ± 0.21 0.18 ± 0.17 **At 80 cm** 0.11 ± 0.14 0.19 ± 0.19 0.16 ± 0.18 **At 90 cm** 0.08 ± 0.14 0.18 ± 0.19 0.14 ± 0.16	0.11 ± 0.15 0.13 ± 0.13 0.11 ± 0.11	Patient satisfaction and CS outcomes were higher with the trifocal IOL than with bifocal IOLs
Kretz et al (2016)[47]	Prospective (3 mo)	Cataract	AT LISA	50 (100)	0.04	**At 66 cm** 0.04	0.01	Patient satisfaction was 80%; low mean spectacle dependence scores; low occurrence of visual disturbances

TABLE 4. (Continued)

Author	Study Design (Follow-Up Period)	Surgery	IOL	Patient (Eyes)	UDVA (logMAR)	UIVA (logMAR)	UNVA (logMAR)	Other Key Findings
Mendicute et al (2016)[51]	Prospective, noncomparative (3 mo)	Cataract	AT LISA	104 (208)	0.03 ± 0.09	0.10 ± 0.15	0.15 ± 0.14	High patient satisfaction and >90% complete spectacle independence; ~80.0% of patients perceived some level of halos though it was not bothersome in 75% of patients
Alfonso et al (2016)[42]	Prospective (6 mo)	RLE	AT LISA	102 (204)	0.11 ± 0.16†	**At 70 cm** 0.12 ± 0.11 **At 60 cm** 0.13 ± 0.10 **At 50 cm** 0.08 ± 0.11	**At 40 cm** 0.07 ± 0.11 **At 30 cm** 0.33 ± 0.14	A reduction of the mesopic CS values both with and without glare vs photopic conditions was observed
Postolache and Postolache‡ (2015)[54]	Prospective, (6 mo)	Cataract	AT LISA AT LISA 809M	18 (36)	0.84 0.88	**At 70 cm** 0.76 0.52	**At 35 cm** 0.68 0.80	Patient satisfaction was very good for both implants and most patients did not request any additional correction
Mojzis et al (2015)[53]	Prospective, consecutive (12 mo)	Cataract	AT LISA	60 (120)	0.03 ± 0.13	**At 80 cm** 0.11 ± 0.13 **At 66 cm** 0.12 ± 0.13	**At 40 cm** 0.27 ± 0.15 **At 33 cm** 0.23 ± 0.15	Significant PCO was found in 19 eyes (15.8%); Nd:YAG capsulotomy was required in 4 eyes (3.3%)
Kohnen et al (2016)[46]	Prospective (6 mo)	Cataract	AT LISA	27 (54)	−0.06 ± 0.10	0.00 ± 0.12	0.04 ± 0.10	High patient satisfaction and spectacle independence; the most common optical phenomena were halos (60%) and glare (28%)
Mojzis et al (2014)[52]	Prospective, comparative (3 mo)	Cataract	AT LISA AT LISA 801	30 (60)	−0.05 ± 0.08 0.00 ± 0.13	**At 80 cm** 0.03 ± 0.08 0.24 ± 0.16 **At 66 cm** 0.06 ± 0.07* 0.29 ± 0.18	**At 40 cm** 0.15 ± 0.09* 0.30 ± 0.15 **At 33 cm** 0.07 ± 0.09* 0.21 ± 0.12	CS was similar with both IOL types
Law et al (2014)[48]	Prospective (6 mo)	Cataract	AT LISA	30 (60)	0.05 ± 0.07§	0.16 ± 0.17§	0.16 ± 0.07	One patient required bilateral Nd:YAG capsulotomy due to clinically significant PCO; overall, there was a high patient satisfaction; 13%–16% reported difficulty in performing intermediate/near tasks; halos and glare were reported in 40% and 13% of patients, respectively
Mojzis et al (2014)[15]	Prospective (6 mo)	RLE	AT LISA	30 (60)	−0.03 ± 0.09	**At 66 cm** 0.08 ± 0.10	**At 33 cm** 0.20 ± 0.12	Total internal aberrations decreased significantly. No serious complications, such as posterior capsule rupture, endophthalmitis, or corneal decompensation occurred during the follow-up

Search term in Medline/PubMed: At LISA (All Fields) AND [trifocal (All Fields) AND IOL (All Fields)]. In total, 49 articles were obtained and a manual search was also performed. Following screening (non-English, optical bench/ in vitro studies; studies not reporting mean VA, meta-analysis and AT LISA toric IOL articles were excluded) and removing duplicates, 16 studies were included. CS, contrast sensitivity; IOL, intraocular lens; logMAR, logarithm of the Minimal Angle of Resolution; Nd:YAG, neodymium-doped yttrium aluminum garnet; PCO, posterior capsular opacification; RLE, refractive lens exchange; SD, standard deviation; UDVA, uncorrected distance visual acuity; UIVA, uncorrected intermediate visual acuity; UNVA, uncorrected near visual acuity; VA, visual acuity.VA is reported in mean ± SD. Unless specified the reported measurements are of binocular uncorrected intermediate (80 cm), and uncorrected near (at 40 cm) VA.

*$P < 0.05$ vs comparator.

†Monocular VA reported.

‡Decimal value reported.

§Distance corrected VA reported.

TABLE 5. A Summary of Uncorrected Visual Acuity Outcomes and Performance Reported for the Symfony EDOF IOL in Clinical Studies

First Author	Study Design (Follow-Up Period)	Surgery	IOL	Patient (Eyes)	UDVA (logMAR)	UIVA (logMAR)	UNVA (logMAR)	Other Key Findings
Hogarty et al (2018)[60]	Retrospective, EDOF targeted for micomonovision (5 mo)	Cataract	Symfony Tecnis monofocal	88 (176)	**At 3 m** −0.04 ± 0.11 −0.02 ± 0.11	**At 1 m** 0.03 ± 0.08* 0.12 ± 0.12 **At 63 cm** 0.09 ± 0.10* 0.24 ± 0.13	0.18 ± 0.08* 0.42 ± 0.15	Spectacle independence was achieved by 63% (distance) and 67% (near) of patients with EDOF IOL
Ganesh et al (2018)[58]	Prospective, EDOF targeted for micomonovision (6 mo)	Cataract	Symfony	25 (50)	−0.036 ± 0.09	**At 80 cm** −0.044 ± 0.09 **At 60 cm** 0.048 ± 0.09	0.152 ± 0.11	Excellent outcomes for far and intermediate vision, satisfactory outcomes for near vision; spectacle independence was achieved by 96% (far and intermediate) and 84% (near); dysphotopsia was reported by 64% (severe in 12%) of patients
Pilger et al (2018)[63]	Prospective, nonrandomized (3 mo)	Cataract	Symfony Tecnis monofocal	30 (60)	−0.02 ± 0.08* −0.06 ± 0.06	**At 80 cm** −0.13 ± 0.07* 0.00 ± 0.06	0.11 ± 0.07* 0.26 ± 0.1	Binocular CS with glare similar to monofocal IOL; spectacle use reported by 40% and 20% for near vision and intermediate vision respectively, in the EDOF group
Pedrotti et al (2018)[62]	Prospective, nonrandomized (6 mo)	Cataract	Symfony Tecnis monofocal Restor +2.5D Restor +3.0D	185 (370)	−0.04 ± 0.09 0.03 ± 0.11 0.00 ± 0.09 0.02 ± 0.08	0.05 ± 0.09* 0.32 ± 0.10 0.00 ± 0.08† 0.29 ± 0.12	0.18 ± 0.10* 0.37 ± 0.11 0.28 ± 0.11 0.05 ± 0.08†	EDOF IOL provided better distance vision (vs all test IOLs) and better intermediate VA than monofocal and Restore multifocal +3.0 D. Spectacle independence was significantly lower with EDOF than with Restore multifocal +2.5 D
Ruiz-Mesa et al (2017)[64]	Prospective, comparative (1 y)	Cataract or RLE	Symfony FineVision	20 (40)	**At 6 m** 0.01 ± 0.02 0.01 ± 0.03	0.09 ± 0.08 0.11 ± 0.08	0.17 ± 0.06 0.06 ± 0.07†	Similar CS, low perception of halos and high patient satisfaction with both IOLs; 5% of patients in FineVision and 10% in Symfony needed occasional spectacles for near vision; 5% of patients in FineVision group had grade 1 PCO
Pedrotti et al (2016)[61]	Prospective, comparative (3 mo)	Cataract	Symfony Tecnis monofocal	40 (80)	**At 6 m** 0.00 ± 0.09 0.03 ± 0.11	0.10 ± 0.09* 0.32 ± 0.10	0.18 ± 0.08* 0.37 ± 0.11	EDOF IOL provided better VA than monofocal at far, intermediate and near distances; CS and optical quality of vision was similar for the 2 IOLs
Cochener (2016)[57]	Prospective case series (4–6 mo)	Cataract or RLE	Symfony (monovision) Symfony (non-monovision)	411 (822)	0.04 ± 0.11 0.03 ± 0.09	0.09 ± 0.17* 0.13 ± 0.16	0.17 ± 0.18 0.21 ± 0.16	High spectacle independence with 14.4% of eyes requiring reading spectacles frequently; high patient satisfaction; >90% reported mild or no photic phenomena; 4.4% of eyes developed PCO requiring Nd:YAG capsulotomy
Sachdev et al‡ (2017)[65]	Prospective, randomized, comparative (4–6 mo)		Symfony	50 (100)	0.89 ± 0.19	**At 70 cm** 0.99 ± 0.13	0.99 ± 0.16	Excellent VA achieved with high levels of spectacle independence. Overall, high patient satisfaction scores and minimal photic phenomena
Hamid and Sokwala‡ (2016)[59]	Prospective, comparative (6 mo)	Cataract or RLE	Symfony AT LISA FineVision	150 (300)	 1.01* 0.96 0.95	**At 80 cm** 0.93* 0.72 0.85	 0.63 0.72† 0.96†	CS significantly better with Symfony vs both trifocals. Halos (20%, 13.3%, and 5.6%) and glare (20%, 13.3%, 5.6%) rated "troublesome" with FineVision, AT LISA and Symfony, respectively. With AT LISA, 6.7% of patients rated glare as disabling. Spectacle independence: 100% for both trifocals, 94% with Symfony. High patient satisfaction (93%–94%) with Symfony and ATLISA while there was 20% patient dissatisfaction with FineVision

Search term in Medline/PubMed: [(extended depth focus) OR extended vision] AND Symfony; (extended depth of focus) AND Symfony; (extended range of vision) AND Symfony. Following screening (non-English, optical bench/in vitro studies, studies not reporting mean VA, meta-analysis and toric IOL articles were excluded) and removing duplicates articles, 9 studies were included. Unless specified the reported measurements are of binocular uncorrected intermediate (60 cm) and uncorrected near (at 40 cm) VA. CS indicates contrast sensitivity; EDOF, extended depth of focus; IOL, intraocular lens; logMAR, logarithm of the Minimal Angle of Resolution; Nd:YAG, neodymium-doped yttrium aluminum garnet; PCO, posterior capsular opacification; RLE, refractive lens exchange; UDVA, uncorrected distance visual acuity; UIVA, uncorrected intermediate visual acuity; UNVA, uncorrected near visual acuity; VA, visual acuity.

*$P < .05$ vs comparator group.

†$P < .05$ vs Symfony.

‡Decimal VA value reported.

the 2 IOL groups at higher frequencies (12 and 18 cpd). Under mesopic conditions without glare, the mixed EDOF group showed better CS at 1.5, 6 and 12 cpd ($P < 0.05$).[18]

Monaco et al (2017)[22] in a randomized clinical trial compared the visual outcomes of PanOptix (n = 20) and Symfony (n = 20) with the monofocal AcrySof IOL (n = 20). Overall, both the multifocal and EDOF IOLs performed significantly better for intermediate and near vision than the monofocal IOL. PanOptix demonstrated significantly better UIVA, UNVA, and corrected near VA than Symfony (Table 2). PanOptix showed a statistically significantly better VA, ~1 line better VA, at defocus level −1.5 D, and from −2.5 D to −4.0 D than the Symfony IOL. Spherical aberration values at 5.0 mm pupil diameter were significantly lower with PanOptix than Symfony. Both the PanOptix and Symfony IOLs had the same level of retinal stray light as the monofocal IOL in the study.[22]

The mean dysphotopsia score in the QoV questionnaire did not show a difference between the PanOptix and Symfony IOLs but their scores were significantly higher in comparison with monofocal SN60WF IOL score. The most frequently reported visual side effect was halo; 15% (n = 3) of patients in the PanOptix group and 25% (n = 5) in the Symfony group rated it as occurring "quite often."[22] Halo was also the most severe and bothersome visual symptom in both the PanOptix and Symfony IOL groups that was rated "moderate" and "quite often" by 15% (n = 3) and 20% (n = 4) of patients with PanOptix and Symfony, respectively. Overall, 85% and 70% of patients with PanOptix and Symfony achieved complete spectacle independence, respectively. In all, 15% (n = 3) of patients in the PanOptix group and 25% (n = 5) in the Symfony group reported spectacle use "sometimes."[22]

Ruiz-Mesa et al (2017)[21] compared VA and optical performance of PanOptix (n = 20) with Symfony (n = 14). In this study, the distance corrected intermediate vision between PanOptix and Symfony was similar, both at 80 cm and 60 cm (Table 2). The preferred reading distance for the 2 IOLs was in the range of 37 to 39 cm. However, a significantly better VA for near and preferred reading distance was achieved with PanOptix than Symfony ($P < 0.001$). The defocus curves showed a comparable pattern for distance and intermediate vision between the 2 IOLs but significantly better near outcomes with PanOptix, from −2.00 D to −4.00 D, than Symfony ($P < 0.001$). PanOptix showed a continuous range vision (VA >0.1 logMAR) from 0.0 to −3.00 D; Symfony had a continuous range vision (VA >0.1 logMAR) from 0.00 to −1.5 D. The CS under photopic and mesopic conditions (evaluated using the Functional Acuity Contrast Test) were similar between the IOL groups at all spatial frequencies and illumination settings. The high order aberrations did not differ significantly between the 2 IOLs. Halometry data showed similar dysphotopic phenomena/perception of halos for both IOLs.[21]

Mencucci et al (2018)[23] compared the 3-month postoperative VA outcomes in patients implanted with PanOptix (n = 20), AT LISA (n = 20), and Symfony (n = 20). The 3 IOLs showed significant differences in intermediate vision (Table 2). PanOptix provided better VA at 60 cm than the other 2 IOLs; similarly, at 80 cm, Symfony was significantly better than the other 2 IOLs. The near vision was relatively better with PanOptix than AT LISA; both IOLs showed significantly better near vision than Symfony (Table 2). The distance CS results were significantly better with Symfony than AT LISA (0.24 logCS, $P < 0.001$) and PanOptix (0.20 logCS, $P < 0.001$) IOLs, under both photopic and mesopic conditions (obtained by adjusting the potentiometer of a halogen lamp according to the room illumination measurements provided by a light meter ST-1300). The 3 IOLs showed similar near reading performance in all parameters (maximum reading speed, critical print size, and reading acuity).[23]

Halos and glare were the most frequently reported visual disturbances by 70% and 50% of patients, respectively, in each group, although the symptoms were rated mostly as mild or, at least, as not disturbing by the patients.[23] In the satisfaction questionnaire, all patients reported complete satisfaction with the choice of IOL. Complete spectacle independence was achieved for distance and intermediate tasks. More patients in the Symfony group (87%) than the AT LISA (33%) and PanOptix (17%) groups reported "often use" of spectacles for near vision.[23]

Escandón-García et al (2018)[24] compared PanOptix (n = 7), FineVision (n = 15), and Symfony (n = 23) and observed no significant difference among the IOLs for distance vision (Table 2). The defocus pattern of the 3 IOLs was different for intermediate vision; Symfony showed a better performance at −1.00 D/1 m ($P = 0.030$), whereas both PanOptix and FineVision provided significantly better near vision at −2.5 D (40 cm; $P = 0.007$) and −3.0 D (33 cm; $P = 0.014$), respectively. PanOptix also showed an improved VA at −2.00 D (50 cm) defocus compared with FineVision and Symfony. There was no significant difference between the IOLs for distance VA (Table 2). The CS performance (evaluated using the Functional Visual Analyzer) was similar among the IOLs under phototopic and scotopic condition; however, the CS of PanOptix was lower at a spatial frequency of 1.5 ($P = 0.049$) in photopic conditions.[24]

Light distortion analysis was measured for size, shape, and regularity of the halo surrounding a source of glare. Light distortion values (ie, light disturbances) were lower with PanOptix than the other 2 IOLs; Symfony showed the highest average values for the distortion index, although the difference was not statistically significant. The QoV questionnaire scores were worst for the Symfony IOL in all categories (frequency, severity, and bothersome scale) than for the other 2 IOLs and the difference was statistically significant for the bothersome subscale.[24]

Cochener et al (2018)[25] did not observe any significant difference in the VA for distance vision (both monocular and binocular) and intermediate VA (monocular) for the PanOptix (n = 20), FineVision (n = 20), and Symfony (n = 20) IOLs (Table 2). Both PanOptix and FineVision IOLs reported significantly better near vision compared with Symfony ($P = 0.002$). The distance CS (evaluated with MTF) was comparable for all 3 IOLs, and CS decreased under mesopic conditions. High-order aberrations were more common in the Symfony group. In the QoV questionnaire, night time visual disturbances, dry eye, halos, and glare were reported by <1% of patients in each IOL group. The proportion of patients with spectacle independence was comparable across all 3 IOLs (89%, 90%, and 86% in the PanOptix, FineVision, and Symfony groups, respectively).[25]

PHOTIC PHENOMENA AND QoL OUTCOMES WITH PANOPTIX

The functional and safety results have been described in the previous section for each study. In all, 8 studies used questionnaires to assess patient satisfaction and visual symptoms.

Perception of halos and difficulty in night driving were the most common visual disturbances reported by patients. The reported incidence of halos showed a wide variation among the studies (<1% to 89%).[10,16,22,23,25] However, the majority of patients reported that the visual side effects had no impact on their QoL. High patient satisfaction and spectacle independence were reported with PanOptix, and there were no reports of patients opting for lens exchange due to photic phenomena in any of the studies.

Incidence of PCO and Nd:YAG capsulotomy was very low with PanOptix; only 1 case was reported across the published studies.[19] Consistent with this finding, Kacerovsky (2018),[68] in a 6-month comparative study (n = 100/per group) observed the PCO rate to be only 0.5% with PanOptix (n = 1) versus 6% (n = 12) with AT LISA ($P = 0.021$).

SUMMARY

Trifocal IOLs have been developed to address the limitations of bifocal IOLs, namely impaired intermediate vision, to improve patient experience after cataract surgery. To create an intermediate vision, the trifocal IOLs split light energy at a third focal point in addition to the far and near zones. Trifocal IOLs achieve a wide range of vision by using different optical designs and technologies, such as diffractive, refractive, and hybrid refractive-diffractive patterns.[5] FineVision Micro F and AT LISA tri 839MP were the first trifocal IOLs introduced and have an intermediate focus at 80 cm. Studies have shown that, in general, these trifocal IOLs provide good VA across all distances, high patient satisfaction, and spectacle independence.[33,34,36,37,40,41] The EDOF IOLs also show good outcomes for far and intermediate vision and limited outcomes for near vision.[58,59,64] An overview of performance of FineVision, AT LISA, and Symfony IOLs in clinical studies is also provided so that the readers can gain an overall perspective on the performance of these MIOLs as well.

AcrySof IQ PanOptix is one of the latest presbyopia-correcting MIOLs based on an optical technology which is unlike that of traditional trifocal IOLs, and is designed to help patients accomplish near and intermediate tasks with greater ease. PanOptix has 3 differentiating features over the trifocals, AT LISA, Fine Vision, and the EDOF IOL Symfony. PanOptix has an intermediate focal point at 60 cm (relaxed arms' length) which is a more natural and comfortable distance to perform routine daily activities versus 80 cm for the trifocals and Symfony [a distance far away for most patients to comfortably reach, 80 cm is the arm's length of a person ~205 cm (ie, 6 ft 8 inches) tall]. Human factor surveys and the Occupational Safety and Health Administration recommend a viewing distance of 20 to 25 inches (~50–63 cm) while performing tasks using digital screens.[69–71] PanOptix also has a higher energy utilization (up to 88%) than both the trifocals (85%–86%), and a smaller diffractive zone (4.5 mm) than trifocals and Symfony (6.0 mm), a feature that makes functional vision to be less dependent on pupil size or lighting conditions and provides better CS.[9,12,19,69,70]

The defocus curves for PanOptix, the trifocal (FineVision, and AT LISA), and Symfony IOLs show a distinct pattern that is consistent with their respective optical designs. For PanOptix, studies consistently showed a good VA over a wide range of defocus levels (+0.50 D and −3.0 D). There was no significant difference among PanOptix, the trifocal IOLs, and Symfony IOL for distance vision. With reference to UIVA (at 60 cm), PanOptix had a better VA performance than Symfony and the trifocals.[10,18,21–23,25] PanOptix performed significantly better for near vision compared with Symfony, FineVision, and AT LISA.[16,23,27] Symfony demonstrated a better intermediate performance than trifocals, and AT LISA and Fine Vision showed better performance at distance and near vision than the EDOF IOL.[67]

Overall, the CS under both photopic and mesopic conditions was similar among the PanOptix, AT LISA, FineVision, and the EDOF IOL, and was found to be within the normal range expected for the age group of patients. The lack of agreement between the CS tests used makes it difficult to directly compare outcomes of different studies.[72]

Halos, glare, and difficulty in night time driving are the most frequently reported visual side effects with PanOptix, and with the trifocals and Symfony IOLs.[16,22–25] A relatively higher frequency or a greater degree of bother is reported with Symfony than with PanOptix and trifocal IOLs for photic phenomena.[22,24] In majority of PanOptix patients photic disturbances had no impact on their daily life and these were reported to decrease with time.[17,27] This phenomenon has been termed as neuroadaptation, wherein patients require a certain postoperative period to adjust to the retinal images, and this is frequently observed with MIOLs.[73] Overall, high patient satisfaction along with complete spectacle independence for all distances (>85% across studies) has been reported with PanOptix.[10,19,22,23,25,26] A limitation that is observed with IOL studies in general is that many of them do not use validated questionnaires to capture patient-related outcomes, and a variation of questionnaires is also used, making it difficult to get a conclusive incidence of photic phenomena.

No specific intraoperative or postoperative complications or adverse events have been reported with PanOptix; the incidence of PCO and Nd:YAG rates was very low.[19] PanOptix belongs to the family of AcrySof hydrophobic IOLs that have been shown to be more stable and have minimal PCO and Nd:YAG capsulotomy rate.[74,75] However, PCO usually has a delayed manifestation and can appear years after the cataract surgery. Apart from 1 study, all other reviewed studies had a maximum of a 6-month postoperative evaluation period, which is insufficient to determine the true incidence of PCO. Thus, long-term follow-up studies with PanOptix are warranted. PCO and Nd:YAG capsulotomy appears to be more common with the AT LISA trifocal IOL than with FineVision and PanOptix.[53,68,76] The reported incidence of PCO with AT LISA is up to 15% to 16% within 1 year of implantation, and up to 35% in the 4-year follow-up period.[53,76] In comparison, the reported PCO rates with FineVison is around 14% during the 4-year period.[76]

A direct comparison of outcomes among studies has several drawbacks, as the studies vary in terms of their design, patient characteristics, methodology, and sample sizes. Furthermore, it is well known that achieving the desired postoperative success and patient satisfaction after IOL surgery is governed by multitude of factors.[77] Each MIOL type offers its own benefits and limitations based on its optical characteristics. Other factors like patients' age and lifestyle, preoperative clinical factors such as preexisting astigmatism, ocular comorbidities, corneal aberrations, previous refractive surgery, and management of possible postoperative complications all play an important role in the final visual outcomes and need to be carefully evaluated while selecting the MIOL.[5,77,78] Hence, this review only provides an overview of the

clinical performance of the presbyopia-correcting IOL PanOptix, as reported in the literature.

Multifocality to some extent compromises the image quality and also reduces CS, and this is often a cause of patient dissatisfaction after MIOL implantation.[77,79] The dysphotopsia associated with MIOLs usually tends to decrease with neuroadaptation. But adaptation is a variable process that depends both on the individual and IOL design, and some patients can find it challenging to wait for vision improvement.[77] Thus, patient selection based on their visual needs and educating them of the potential optical side-effects that they may experience after an MIOL implantation, some of which may never resolve, is essential in setting realistic expectations. Patient personality traits have been shown to influence success with MIOLs.[77,80]

In conclusion, MIOLs have today become very popular in the management of cataract and refractive error. With advances in technology, a range of MIOLs are available that can cater to a wide range of patients' needs. The key is to identify the most suitable MIOL according to an individual's personality, expectations, and preoperative condition, so as to yield best possible visual outcomes with maximum patient satisfaction and an enhanced QoL.

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