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Research Article

Comparative Results of the Trifocal Intraocular Lens with the Enhanced Depth of Focus Intraocular Lens in Cataract Surgery

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Abstract

Purpose: To evaluate the visual, refractive, defocus curve and contrast sensitivity outcomes of the trifocal intraocular lens with the enhanced depth of focus (Mono-EDOF) intraocular lens in cataract surgery.

Patients and methods: A prospective, randomized, comparative case series study was conducted at two clinical centers. Patients underwent cataract surgery with implantation of the TECNIS Synergy ZFR00V IOL (group 1) and the TECNIS Eyhance ICB00 IOL (group 2) from January 2025 to August 2025. Results are reported 3 months post-surgery.

Results: A total of 80 eyes of 46 patients were operated (40 eyes of 22 patients in group 1 and 40 eyes of 24 patients in group 2). The mean logMAR Uncorrected Distance Visual Acuity (UDVA) was 0.03 ± 0.05 and 0.01 ± 0.03 in the group 1 and group 2 respectively, with a statistically significant difference ($p<0.05$). The mean logMAR Uncorrected Intermediate Visual Acuity (UIVA) was 0.19 ± 0.10 and 0.28 ± 0.06 in the group 1 and group 2 respectively, with a statistically significant difference ($p<0.001$). The mean logMAR Uncorrected Near Visual Acuity (UIVA) was 0.08 ± 0.08 and 0.49 ± 0.07 in the group 1 and group 2 respectively, with a statistically significant difference ($p<0.001$). Contrast sensitivity was within normal levels for age but lower in the group 1 in all 4 spatial frequencies evaluated.

Conclusion: The Synergy IOL demonstrated excellent but lower levels of distance vision compared to the Eyhance IOL, but with better intermediate and near vision, maintaining normal levels of contrast sensitivity but lower than the Eyhance IOL at all 4 frequencies evaluated.

Keywords: Trifocal Intraocular Lens; Enhanced Depth of Focus Monofocal Intraocular Lens; Presbyopia

Introduction

Cataract surgery with intraocular lens implantation in the posterior chamber has been the routinely performed procedure worldwide for the last five decades [1]. The World Health Organization estimated that 32 million cataract surgeries were performed globally in 2020 [2]. Monofocal intraocular lenses continue to be the most frequently implanted due to their low cost, their effectiveness in providing excellent distance vision, their low incidence of undesirable photoptic phenomena (halos and glare) and their excellent contrast sensitivity under different lighting conditions [3]. Monofocal intraocular lenses focus light at a single focal point, providing excellent distance vision; however, the quality of vision at other distances is insufficient for performing daily activities that involve vision at shorter distances; therefore, most patients with monofocal intraocular lenses need to wear glasses for activities that require near and intermediate vision (33 cm and 66 cm) [4]. This aspect is especially important in elderly patients, since the use of bifocal or progressive glasses is associated with an increased risk of falls in this age group [5]. To improve vision at different distances, multifocal intraocular lenses appeared, which divide the incident light into 2 or more focal points [6]. Trifocal Intraocular Lenses (IOLs) such as the Panoptix IOL (Alcon Laboratories), the FineVision IOL (Physiol) and the TECNIS Synergy IOL (Johnson and Johnson Vision) offer spectacle independence because they produce good functional results for distance, intermediate and near vision [7]. Compared to monofocal IOLs, they offer better near and intermediate vision quality and are superior to bifocal IOLs for intermediate vision [8,9]. Due to their diffractive optics, multifocal IOLs, which distribute light across two focal points (bifocal IOLs) and three focal points (trifocal IOLs), create an overlap of the different images formed, with only one image focused on the retina. Because of this, multifocal IOLs are associated with photoptic phenomena (dysphotopsias) and decreased contrast sensitivity [10]. The redistribution of light produces a decrease in contrast sensitivity and the overlapping of images is perceived as halos. The difractive rings of the optics cause light scattering, perceived as glare [11].

In recent years, the importance of intermediate vision in modern life has increased due to the significant rise in activities involving this type of vision (computer screens, laptops, smartphones, tablets, etc.) and these activities have been adopted with increasing frequency precisely by the elderly age group, who are more susceptible to cataract surgery [12,13]. This has led to growing interest in reducing dependence on glasses for intermediate vision without the undesirable effects (dysphotopsias) of multifocal IOLs, thus improving quality of life in several aspects [11,14]. Recently, Extended Depth of Focus (EDOF) IOLs have emerged, offering an extended range of focus [15]. Depth of focus is the amount of image displacement behind the lens that does not degrade the perceived image quality or the eye's tolerance to retinal blur; a wide depth of focus allows for sharp images of objects at near distances [16]. In 2014, Extended Depth of Focus (EDOF) IOLs were introduced, offering an extended focus range that produces good, functional distance and intermediate vision with a gradual and monotonous decrease in visual acuity from the best distance focal point [13]. Consequently, EDOF IOLs provide functional vision over a wide range of distances, reducing the incidence of dysphotopsia, but with near vision inferior to multifocal IOLs [14,15].

The American National Standards Institute (ANSI) published clinical criteria in 2018 to define EDOF IOLs [15]. According to these monocular criteria, an EDOF IOL must have the following: (1) a depth of focus (negative defocus induced in the defocus curve) >0.5 diopters (D) greater than a control group of monocular IOLs with a visual acuity of 0.2 logMAR (20/32 Snellen); (2) an intermediate visual acuity at 66 cm (with best distance correction) statistically superior to a control group of monocular IOLs; (3) an intermediate vision at 66 cm (with best distance correction) of 0.2 logMAR or better; (4) a best-corrected distance visual acuity not inferior to that provided by a monocular IOL of 0.1 logMAR (20/25 Snellen).

Several optical principles can be applied to extend the range of vision for patients [17,18]. The most commonly used are diffractive optics (Symphony IOL, Johnson and Johnson Vision), the small-aperture design (pinhole effect) of the IC-8 IOL (AcuFocus, Inc., Irvine, CA), non-diffractive IOLs that use spherical aberrations (Mini WELL Ready IOL, Catania, Italy and LuxSmar, Bausch and Lomb GmbH, Berlin, Germany) and IOLs with a segmented refractive design to increase depth of focus (Vivity IOL, Alcon Laboratories) [17-20].

The Enhanced Depth of Focus Monofocal IOLs (Mono-EDOF) were developed to create a discrete increase in depth of focus while maintaining all the benefits of Monofocal IOLs, such as low incidence of dysphotopsia and high image quality [21,22]. The TECNIS Eyhance IOL, the first commercially available Mono-EDOF IOL, effectively improves intermediate vision compared to Monofocal IOLs [21-23].

However, according to Fernández, et al., Mono-EDOF IOLs do not possess an extended range of vision that meets the criteria of the American National Standards Institute [15,24].

The purpose of this study is to present the visual, refractive, defocus curve and contrast sensitivity results of the TECNIS Synergy ZFR00V Trifocal IOL with the TECNIS Eyhance ICB00 Mono-EDOF IOL, 3 months post-surgery.

Materials and Methods

Study Design and Participants

A prospective, randomized, comparative case series study was conducted at two clinical centers. Patients underwent cataract surgery with implantation of the TECNIS Synergy ZFR00V IOL (group 1) and the Eyhance ICB00 IOL (group 2) from January 2025 to August 2025. The selection criteria were patients with bilateral cataracts, corneal astigmatism <1.0 D or clear lenses with presbyopia, hyperopia >1.0 D or myopia >1.0 D. Patients older than 85 years, those with axial lengths greater than 26.0 mm or less than 22.5 mm (due to decreased predictability of IOL calculation), a history of previous refractive surgery, dry eye, ocular surface disorders, maculopathy, glaucoma and diabetes were excluded. Informed consent was obtained from all patients prior surgery. The study followed the tenets of the Declaration of Helsinki.

All patients were examined preoperatively and on days 1, 7, 15 and 3 months postoperatively. A complete ophthalmological examination was performed preoperatively and 3 months postoperatively, including: Uncorrected Distance Visual Acuity (UDVA), uncorrected intermediate visual acuity at 66 cm (UIVA) and Uncorrected Near Visual Acuity at 33 cm (UNVA), manifest refraction, slit-lamp examination, retinal examination (performed by a retina specialist), Goldman tonometry and contrast sensitivity testing.

Surgical Procedure

All surgeries were performed under peribulbar anesthesia by an experienced surgeon (A.P.F.). A 2.2 mm clear corneal incision was created at 110° and a 1.5 mm lateral paracentesis was performed at 0°. The Veritas phacoemulsification system (Johnson and Johnson Vision) and the R-Evolution system (BVI Medical) were used in all surgeries. The "stop and chop" technique was used for phacoemulsification. The IOL was implanted using the TECNIS SIMPLICITY Delivery System preloaded. At the end of the surgery, an intracameral antibiotic (moxifloxacin) was administered and the eye was patched. The following day, all patients were examined and prescribed a combination of moxifloxacin and dexamethasone eye drops six times a day, along with artificial tears.

Intraocular Lens Features

The TECNIS Synergy ZFR00V IOL (Johnson and Johnson Vision) is a foldable, one-piece, hydrophobic acrylic lens with a violet-blocking filter. It features a +3.5 D addition to the IOL plane and a hybrid design that combines multifocal technology with Extended Depth of Focus (EDOF) to provide uninterrupted vision from distance to near with high-contrast images. With biconvex optics, its anterior surface features an aspheric wavefront design with a negative spherical aberration of -0.27 µm, while its posterior surface has a diffractive surface of 15 concentric rings to elongate the depth of focus and correct chromatic aberration for enhanced contrast sensitivity. It has a total diameter of 13 mm, an optical zone of 6 mm and a refractive index of 1.47 at 35°C. It is available in powers from +5.0 D to +34.0 D in 0.5 D increments. The IOL has a continuous ground back square edge in 360°.

The TECNIS Eyhance ICB00 IOL (Johnson and Johnson Vision) is a foldable, one-piece, hydrophobic acrylic lens with a violet-blocking filter. It has a total diameter of 13.0 mm and a 6.0 mm diameter optical zone. It features a refractive optical zone with an aspheric anterior surface and progressive continuous power. This refractive profile increases in power continuously from the periphery to the center of the IOL [21-23]. The IOL is designed to effectively improve intermediate vision while maintaining distance vision comparable to that of the one-piece TECNIS One Monofocal IOL. The spherical aberration compensation of its anterior surface is -0.27µm, which minimally alters its surface profile, making it indistinguishable from the one-piece TECNIS One Monofocal IOL ZCB00 (they share the same platform). It is available with the preloaded TECNIS SIMPLICITY Delivery System.

The Intraocular Lens (IOL) dioptric power was calculated to achieve emmetropia in both eyes and measurements (biometry) were performed using the Oculus Pentacam AXL (Wetzlar, Germany) and the EYESTAR 900 (Haag-Streit Group, Köniz, Switzerland) with the Barrett Universal II formula.

Postoperative Outcome Measures

Monocular Corrected Distance Visual Acuity (CDVA) and Uncorrected Distance Visual Acuity (UDVA) were measured at 3 months after surgery using an Early Treatment Diabetic Retinopathy Study (ETDRS) chart (Precision Vision, Woodstock, IL, USA). Monocular uncorrected intermediate visual acuity (UIVA at 66 cm) and uncorrected near visual acuity (UNVA at 33 cm) were assessed using handheld ETDRS vision cards (Precision Vision, Woodstock, IL, USA). Visual acuity measurements were converted to the logarithm of the minimum angle of resolution (logMAR) for statistical analysis.

A monocular defocus curve was performed at a distance of 3 meters (with the best distance correction-manifest refraction) 3 months after surgery, with additions from +3.0 D to -5.0 D, in 0.5 D steps. Contrast sensitivity was measured under mesopic conditions without glare with the CSV-1000 test (target luminance: 3 cd/m^2) using manifest refraction at 4 spatial frequencies (3, 6, 12 and 18 cycles per degree).

Statistical Analysis

For the analysis of the results, all quantitative variables were expressed using measures of central tendency and dispersion. All variables were previously assessed for the normality of their distribution using the Kolmogorov-Smirnov test. According to this test, the variables did not present a normal distribution (Gaussian curve), therefore the non-parametric Mann-Whitney U test for independent samples was used to compare the results between groups. A difference was considered statistically significant when the p-value was <0.05. The results were processed using the IBM SPSS Statistics statistical software, version 31.0.0.0.

Results

A total of 80 eyes of 46 patients were operated (40 eyes of 22 patients in group 1 and 40 eyes of 24 patients in group 2). The preoperative patient demographics are shown in Table 1. The mean (± SD) age was 61.53 ± 7.75 and 66.4 ± 7.95 years in the Synergy ZFR00V and Eyhance ICB00 IOL groups respectively and there were more females in both IOL groups.

No intra or post-operative complications, such as endophthalmitis, secondary glaucoma or cystoid macular edema, were reported. All participants included in the analysis were followed up for three months after cataract surgery.

The visual and refractive outcomes at three months postoperatively are shown in Table 2. The mean logMAR Uncorrected Distance Visual Acuity (UDVA) was 0.03 ± 0.05 and 0.01 ± 0.03 in the groups 1 and 2 respectively, with a statistically significant difference (p<0.05). The mean logMAR uncorrected intermediate visual acuity (UIVA) was 0.19 ± 0.10 and 0.28 ± 0.06 in the groups 1 and 2 respectively, with a statistically significant difference (p<0.001). The mean logMAR Uncorrected Near Visual Acuity (UIVA) was 0.08 ± 0.08 and 0.49 ± 0.07 in the groups 1 and 2 respectively, with a statistically significant difference (p<0.001).

The mean postoperative spherical equivalent in groups 1 and 2 was 0.03 ± 0.22 D (range, 0.5 to 0.0 D) and 0.004 ± 0.26 (range, -0.25 to 0.5 D), respectively, with no statistically significant difference (p=0.492) (Table 2).

The average postoperative cylinder in group 1 and 2 was -0.31 ± 0.25 D (range, -0.25 to -0.75 D) and -0.20 ± 0.18 D (range, -0.25 to -0.75 D) respectively, with no statistically significant difference (p=0.325) (Table 2). All eyes (100%) were within ± 0.5D of emmetropia postoperatively. The cumulative uncorrected visual acuity in groups 1 and 2 are shown in Fig. 1-3. The percentage of eyes that had an uncorrected visual acuity for distance, intermediate and near >20/30 in group 1 was 100%, 72.5% and 95% respectively and in group 2, 100%, 20% and 0% respectively.

The monocular defocus curve in group 1 showed that the mean logMAR VA for distance (0 D defocus) was 0.05 (approx. 20/25+ Snellen), for intermediate (-1.5 D defocus) was 0.18 (20/30 Snellen) and for near (-3.0 D defocus) was 0.11 (20/25 Snellen). In group 2, the monocular defocus curve showed that the mean logMAR VA for distance (0 D defocus) was 0.011 (approx. 20/20 Snellen), for intermediate vision (-1.5 D defocus) was 0.313 (approx. 20/40 Snellen) and for near vision (-3.0 D defocus) was 0.533 (approx. 20/70 Snellen) (Fig. 4).

Contrast sensitivity under mesopic conditions without glare is shown in Fig. 5. Mean contrast sensitivity values in logMAR units were observed to be above 1.35 for frequencies of 3 and 6 cycles per degree (cpd) and a drop at higher frequencies (1.2 at 12 cpd and 0.8 at 18 cpd) for group 1. For group 2, the mean contrast sensitivity values were above 1.35 for frequencies of 3, 6 and 12 cpd and 0.9 for 18 cpd. Contrast sensitivity was within normal levels for age in both groups but was better in group 2 (Eyhance IOL) at all 4 frequencies evaluated, with a statistically significant difference (p<0.001).

Baseline Characteristics	Synergy ZFR00V	Eyhance ICB00
Patients /eyes (n)	22/40	24/40
Age (years)	61.53 ± 7.75	66.4 ± 7.95
Sex: n (%) Female	33 (82.5)	29 (72.5)
Male	7 (17.5)	11 (27.5)

Table 1: Preoperative patient demographics.

Intraocular Lens	Synergy ZFR00V	Eyhance ICB00	p-Value
UDVA (logMAR)	0.03 ± 0.05	0.01 ± 0.03	0.007*
BCVA (logMAR)	0.01 ± 0.03	0.01 ± 0.02	0.25
UIVA (logMAR)	0.19 ± 0.10	0.28 ± 0.06	< 0.001*
UNVA (logMAR)	0.08 ± 0.08	0.49 ± 0.07	< 0.001*
Spherical equivalent (D) Cylinder D)	0.03 ± 0.22 -0.31 ± 0.25 D	0.004 ± 0.26 -0.20 ± 0.18 D	0.492 0.325
Values are presented as mean ± standard deviation. LogMAR, logarithm of the minimal angle of resolution; D, diopters; UDVA, uncorrected distance visual acuity; BCVA, best corrected visual acuity; UIVA, uncorrected intermediate visual acuity; UNVA, uncorrected near visual acuity. * p<0.05 statistically significant difference.			

Table 2: Visual and refractive outcome at postoperative three months.

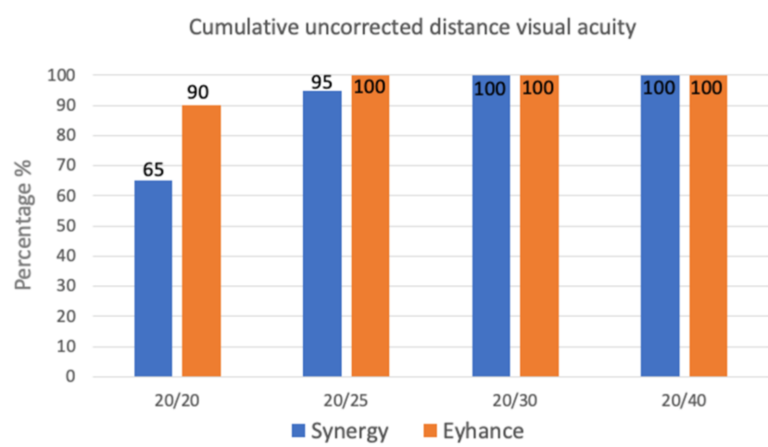

Figure 1: Cumulative uncorrected distance visual acuity 3 months after surgery.

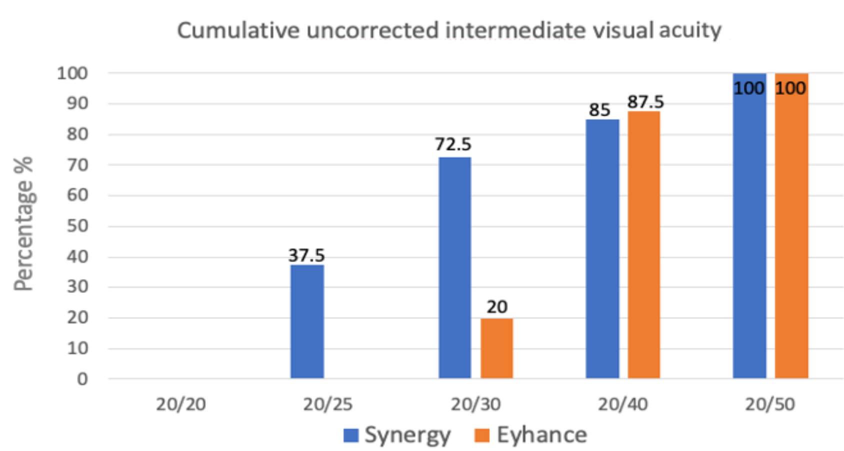

Figure 2: Cumulative uncorrected intermediate visual acuity 3 months after surgery.

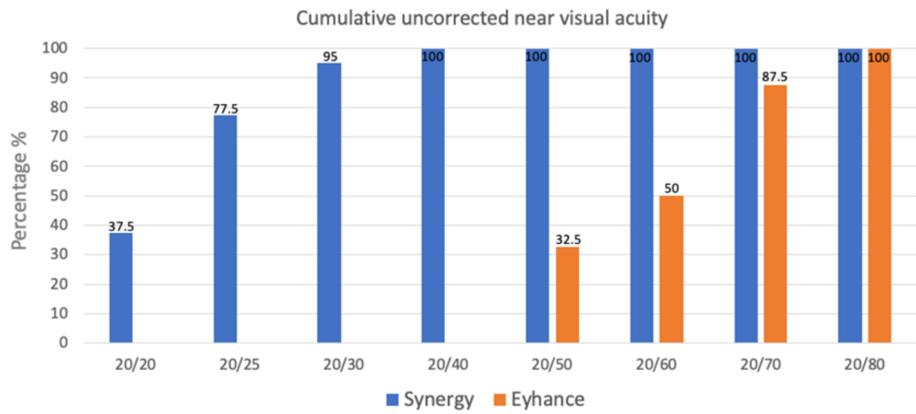

Figure 3: Cumulative uncorrected near visual acuity 3 months after surgery.

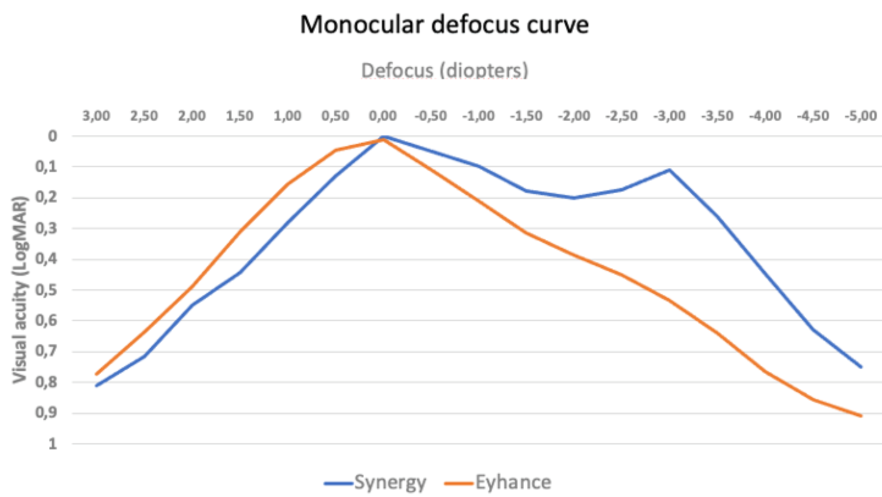

Figure 4: Monocular defocus curve 3 months after surgery.

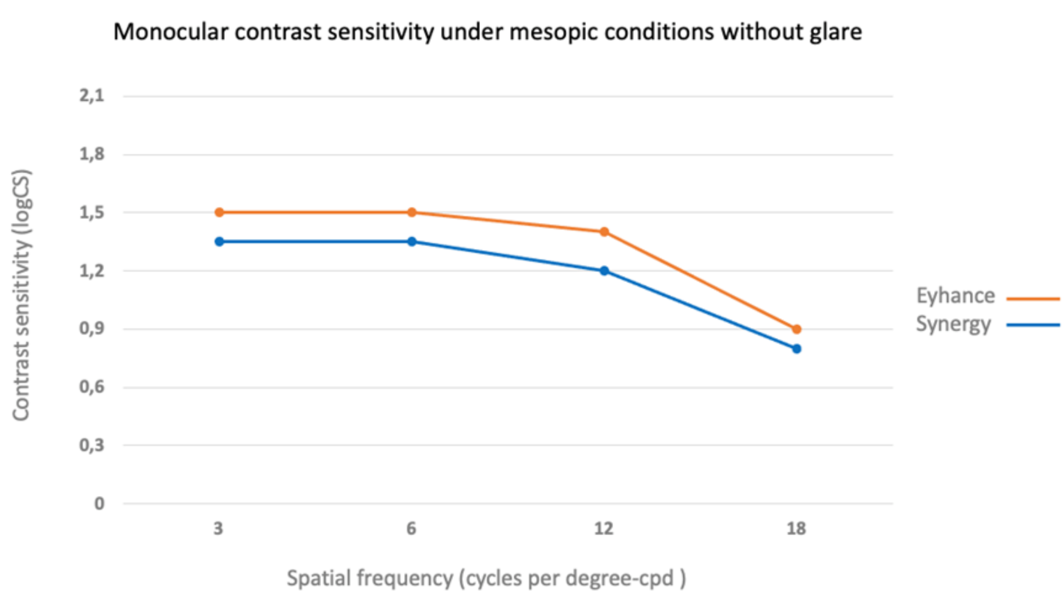

Figure 5: Monocular contrast sensitivity under mesopic conditions without glare 3 months after surgery.

Discussion

Multifocal IOLs and EDOF IOLs have been shown to provide better visual acuities for intermediate and near vision compared to monofocal IOLs [4,6,7,9,11,14,17,21]. In one study, Morshirfar, et al., reported a cumulative Uncorrected Visual Acuity (UCVA) ≥20/30 for distance 3 months after Panoptix IOL implantation in one group (29 eyes) and Symfony IOL implantation in another group (48 eyes) of 86% and 73%, respectively [25]. In the same study, they reported a cumulative UCVA ≥20/30 for near after Panoptix and Symfony IOL implantation of 77% and 71%, respectively. Intermediate UCVA results were not reported in that study. In another study of 190 eyes with the Panoptix trifocal IOL (Alcon Laboratories), Centurion reported a cumulative UCVA ≥20/30 for distance, intermediate and near vision 2 months post-surgery of 98.95%, 100% and 100%, respectively [26]. The results reported in our study for distance and near vision (100% and 95%) are similar to those reported by Centurion, but the percentage of cumulative UCVA ≥20/30 for intermediate vision is lower in our study (72.5% vs. 100%) [26]. Visual assessments in our study were performed monocularly, which may produce lower results than those reported in other studies using binocular visual assessments.

In a multicenter study that included 135 eyes implanted with the TECNIS Synergy IOL, a cumulative UCVA ≥20/30 for distance, intermediate and near vision was reported at 6 months postoperatively in 87.7%, 95.4% and 82.4% of cases, respectively [27]. The same study reported a postoperative spherical equivalent of ± 0.5 D from emmetropia in 88.5% of eyes; however, they mention that IOL power calculations were performed using different formulas according to the surgeon's preference. In our study, we used only the Barrett Universal II formula and 100% of eyes were within 0.5D of emmetropia.

In another multicenter study, visual outcomes and defocus curves were compared between the TECNIS Synergy IOL (93 eyes) and the Panoptix IOL (53 eyes) implanted three months post-surgery [28]. The Synergy IOL showed significantly better visual performance for both distance vision and reading distances (40 cm and 33 cm), including several visual assessments under photopic and mesopic conditions. The Synergy IOL group exhibited a wider range of vision, from distance to near vision. Furthermore, the hydrophobic acrylic material used in AcrySof IOLs (the Panoptix IOL platform, Alcon Laboratories) is associated with greater chromatic aberrations, a factor that may contribute to the inferior visual outcomes. The formation of shiny microvacuoles ("glistenings", the term used to describe them) in the IOL optics associated with the AcrySof material produces light scattering, which can reduce visual quality over time [29]. Different studies suggest that these "glistenings" continue to increase over time [29-31].

In our study, the mean logMAR UDVA for the Synergy IOL and the Eyhance IOL was 0.03 ± 0.05 and 0.01 ± 0.03 respectively, with a statistically significant difference ($p<0.05$), with the Eyhance IOL group having better distance visual acuity. The percentage of eyes that had an UDVA of 20/20 in group 1 and 2 was 65% and 90 % respectively. The mean postoperative spherical equivalent in both groups was very similar, with no statistically significant difference ($p=0.492$). This inferior result of the Synergy IOL in distance visual acuity is probably due to its diffractive optics, which produces a redistribution of light in the different foci [10,11].

In this study, when comparing group 1 (Synergy IOL) and group 2 (Eyhance IOL), we found that the UIVA and UNVA were better in group 1, with a statistically significant difference ($p<0.001$). However, it should be noted that the Eyhance IOL group had a functional UIVA of 0.28 ± 0.06 logMAR (approx. 20/40 Snellen), better than the reported for Monofocal IOLs.

When evaluating the defocus curves of our patients (Fig. 4), which were assessed monocularly, we found the maximum peak vision for both IOLs at 0 D defocus, with an average vision of 0.01 logMAR for both IOLs (20/20 Snellen). As negative defocus increased (0 to -1.5D), the Synergy IOL showed a progressively decreasing and smooth curve, achieving 0.18 logMAR (≥20/30 Snellen), performing better than the Eyhance IOL (0.313 logMAR, approximately 20/40 Snellen). With subsequent defocus levels, from intermediate to near vision, the Synergy IOL achieved a logMAR vision of 0.112 (approximately 20/25 Snellen) with a defocus of -3.0 D, compared to Eyhance IOL (0.533 logMAR, approximately 20/70 Snellen).

According to the criteria established by the American National Standards Institute (ANSI), the TECNIS Eyhance IOL does not meet all the criteria to be classified as an EDOF IOL [15]. Fernandez, et al., conducted a review of published scientific articles on enhanced monofocal (Mono-EDOF) IOLs to determine if they meet all the criteria established by ANSI [24]. They studied 2 systematic reviews, 13 laboratory studies, 21 clinical studies and 2 mixed studies. The study included those that reported results with the TECNIS Eyhance IOLs (Johnson and Johnson), IsoPure (Physiol), Xact (Santen), Zoe (OphthalmoPro GmbH), RayOne

EMV (Rayner), Lentis Quantum (Teleon Surgical), Evolux (Sifi), Vivinex Impress (Hoya) and Extend HP (Hanita Lenses). The majority of the evidence found (74%) in this review comes from studies related to the TECNIS Eyhance IOL. These studies concluded that these Mono-EDOF IOLs do not meet all the criteria established by ANSI for classification as EDOF and suggest continuing to call them Enhanced Monofocal IOLs or Mono-EDOF. In terms of visual outcomes, the main difference found, compared to EDOF IOLs, was the lower near visual acuity. Regarding intermediate vision outcomes, no statistically significant difference was found between EDOF IOLs and Mono-EDOF IOLs [32,33].

Ribeiro, et al. and Fernández, et al., propose a new (functional) classification of premium IOLs, now called Simultaneous Vision IOLs (SVIOLs) [34,35]. This classification is based on the "Depth of Field" (DOFi) measured monocularly with the defocus curves, with the best distance correction (manifest refraction). It has been described as evidence-based because the scientific method has been the cornerstone of its development. They identify two categories of SVIOLs, according to the depth of field and the shape of the defocus curves: (1) Partial Depth of Field IOLs (Partial-DOFi) and (2) Full Depth of Field IOLs (Full-DOFi). Within the first category (Partial-DOFi) are three subcategories: (1.1) Narrowed, (1.2) Enhanced and (1.3) Extended, that reflect a progressive increase in DOFi accompanied by a gradual compromise in far distance visual quality. In the second category, Full-DOFi, the subcategories depend on the increase in the curve between intermediate and near vision. These are: (2.1) Steep, (2.2) Smooth and (2.3) Continuous, that represent a progressive enhancement in intermediate visual performance, which may be associated with a corresponding progressive reduction in near visual quality. It is beyond the scope of this article to define each of the subcategories; however, it is necessary to mention that Mono-EDOF Eyhance IOL correspond in this classification to the subcategory of Partial-DOFi Enhanced IOLs, with the following characteristics: achieving a visual acuity of 0.2 logMAR (20/32 Snellen) with a defocus between >1.2 and <1.58 D and a visual acuity of 0.3 logMAR (20/40 Snellen) with a defocus between >1.58 and <2.3 D. Similarly, the Synergy IOL belongs to the subcategory Full-DOFi Smooth IOL, with the following characteristics: achieving a visual acuity of 0.2 logMAR (20/32 Snellen) with a defocus >2.3 D and a visual acuity of 0.3 logMAR (20/40 Snellen) with a defocus >2.75 D.

Contrast sensitivity depends on the age of the patients, regardless of cataract development [36,37]. When comparing the contrast sensitivities of 2 different IOLs, a difference of more than 0.3 logMAR contrast sensitivity units (logMAR CS) is considered clinically relevant if it occurs at 2 or more spatial frequencies (3, 6, 12, 18 cpd) [38]. For the 50-75 age group, normal contrast sensitivity under photopic conditions is 1.56 ± 0.15, 1.80 ± 0.165, 1.50 ± 0.15 and 0.93 ± 0.25 logMAR CS units for 3, 6, 12 and 18 cpd, respectively [23]. Under mesopic conditions (as we evaluated it in our study) there are no published values available in normal eyes in that age group; The average age in our study was 61.53 ± 7.75 years in groups 1 and 66.4 ± 7.95 years in groups 2. It is expected that the results will be lower than those obtained under photopic conditions [36]. In this study, contrast sensitivity was within these limits in both groups, but it was better in the Eyhance IOL group at all four frequencies evaluated (Fig. 5), with a statistically significant difference (p<0.001). This decrease in contrast sensitivity in the Synergy IOL group is probably due to its diffractive optics, which produce a redistribution of light at different focal points [10,11].

In our study, we did not report values for the incidence and intensity of dysphotopsia in the postoperative period; however, at 3 months postoperatively, the incidence was <5%. Dysphotopsia is associated with the implantation of multifocal IOLs [3,10,11]. The TECNIS Synergy IOL has a filter for the violet light wavelength, designed to reduce dysphotopsia (halos, night glare and dazzlement) [39]. These dysphotopsias tend to decrease until 6 months postoperatively [40]. Despite adaptation to the new retinal images (neuroadaptation), a small proportion of patients will always experience dysphotopsia. It is not always possible to predict which patients will experience this persistence of dysphotopsia over time [40]. Large case series with longer follow-ups are necessary to assess the long-term visual outcome. Finally, tests should be administered to determine the incidence and severity of dysphotopsia and questionnaires should be used to assess patient satisfaction.

Conclusion

In conclusion, the results of our study demonstrate the efficacy and safety of the Synergy and Eyhance IOLs. The Synergy IOL provides excellent levels of distance, intermediate and near vision. The Eyhance IOL group showed a higher percentage of eyes achieving 20/20 of uncorrected distance visual acuity. The Synergy IOL provides a high degree of independence from corrective lenses (glasses) for distance, intermediate and near vision. While contrast sensitivity was within normal limits in both IOL groups, the Eyhance IOL showed better results at all four frequencies evaluated.

Conflict of Interest
The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

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Data Availability Statement
The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Ethical Statement
The project did not meet the definition of human subject research under the purview of the IRB according to federal regulations and therefore was exempt.

Informed Consent Statement
Informed consent was obtained from all participants included in the study.

Authors' Contributions
All authors contributed equally to this paper.

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