

# Objective and subjective visual outcome comparison analysis of two diffractive presbyopic correcting intraocular lenses

Análise comparativa dos resultados visuais objetivos e subjetivos de duas lentes intraoculares difrativas para correção da presbiopia

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## ABSTRACT

This case series evaluates the visual outcomes of two trifocal intraocular lenses, the ZFR00V and TNFT00, in cataract surgery patients. Nineteen patients (38 eyes) were bilaterally implanted with one of the two intraocular lenses. Postoperative assessments included uncorrected and corrected distance, intermediate, and near visual acuities, as well as patient-reported satisfaction and photic phenomena. Both intraocular lenses provided satisfactory visual performance for distance and intermediate vision. However, the ZFR00V intraocular lenses demonstrated superior near vision, particularly in the defocus range between -1.50 D and -3.00 D. Despite these differences, patient satisfaction levels were comparable between groups, with photic phenomena reported at similar frequencies. These findings highlight the importance of individualized intraocular lens selection based on each patient's visual needs.

## RESUMO

Esta série de casos avalia os resultados visuais de duas lentes intraoculares trifocais, ZFR00V e TNFT00, em pacientes submetidos à cirurgia de catarata. Dezenove pacientes (38 olhos) receberam implantes bilaterais de uma das duas lentes intraoculares. As avaliações pós-operatórias incluíram acuidade visual não corrigida e corrigida para longe, intermediária e perto, além da satisfação do paciente e a ocorrência de fenômenos fopsias. Ambas as lentes intraoculares proporcionaram desempenho visual satisfatório para visão de longe e intermediária. No entanto, a LIO ZFR00V demonstrou melhor desempenho na visão de perto, especialmente na faixa de desfocalização entre -1,50 D e -3,00 D. Apesar dessas diferenças, os níveis de satisfação dos pacientes foram semelhantes entre os grupos, com fenômenos fopsias relatados em frequências comparáveis. Esses achados ressaltam a importância da seleção individualizada da lente intraocular com base nas necessidades visuais de cada paciente.

## INTRODUCTION

Cataract surgery has evolved beyond restoring visual clarity to become a refractive procedure to achieve spectacle independence. Advances in intraocular lens (IOL) technology, particularly trifocal diffractive designs, enable better performance across near, intermediate, and distance vision. However, these advancements have potential drawbacks, including visual disturbances such as halos and glare. A deeper understanding of the performance characteristics of these lenses is essential for guiding clinical decision-making and optimizing patient outcomes.<sup>(1-4)</sup>

The ZFRooV (Tecnis Synergy, Johnson & Johnson) and TNFToo (Acrysof Panoptix, Alcon) are widely used trifocal IOLs, each employing unique optical designs. The ZFRooV lens integrates advanced chromatic aberration correction to improve contrast sensitivity and depth of focus<sup>(6)</sup>. The TNFToo lens features a non-apodized trifocal design aimed at distributing light energy efficiently across three focal points: near, intermediate, and distance. Both lenses have demonstrated high levels of spectacle independence and patient satisfaction in controlled clinical settings.<sup>(5-10)</sup>

This case series compares these lenses' objective and subjective outcomes in a real-world clinical setting. It focuses on visual acuity at various distances, defocus curve analysis, and patient-reported quality of life. The findings provide valuable insights for clinicians who customize IOL selection to individual patient needs.

All patients included in this study gave informed consent. Because this case series included more than three patients, Institutional Review Board (IRB) approval was granted. The study adhered to the tenets of the Declaration of Helsinki. Ethics approval and consent to participate: all patients signed informed consent. The study was approved by the Ethics Committee of the Hospital Oftalmológico de Brasília (76675320.6.0000.5667)

## CASE REPORTS

Nineteen patients (38 eyes) underwent bilateral implantation of either the ZFRooV or TNFToo IOL, meeting strict inclusion criteria: bilateral cataracts, no significant ocular comorbidities, and high preoperative visual potential. Cases involving prior refractive surgery or postoperative refractive errors were excluded. All surgeries were performed by the same experienced surgeon following a standardized protocol.

### Visual and subjective outcomes

Objective visual outcomes revealed excellent distance and intermediate vision performance for both lenses.

Notably, the ZFRooV lens demonstrated a clear advantage in near-vision tasks. Uncorrected near visual acuity (UNVA) at 40 cm averaged 0.10 logMAR in the ZFRooV group, significantly outperforming the TNFToo group, which achieved a mean of 0.15 logMAR ( $p < 0.05$ )<sup>11</sup>. Intermediate and distance visual acuities were statistically comparable, highlighting the robustness of both IOLs in these domains.

Monocular defocus curve analysis reinforced the superior near-vision capabilities of the ZFRooV lens. Between defocus levels of -1.50 D and -3.00 D, the ZFRooV consistently outperformed the TNFToo, providing sharper vision for near tasks. This difference was statistically significant, with effect sizes indicating moderate clinical relevance. (Figure 1)

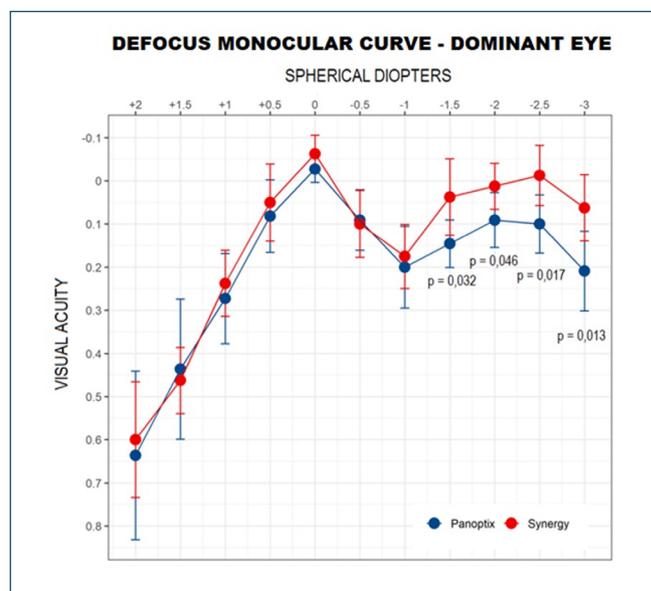


Figure 1. Defocus monocular curve in the dominant eye.

Subjective measures corroborated these findings. Approximately 88% of patients in the ZFRooV group reported being “very satisfied” with their outcomes, compared to 91% in the TNFToo group. Despite the ZFRooV lens's superior near performance, overall satisfaction levels were similar, reflecting the high quality of both lenses. Commonly reported photic phenomena, including halos and glare, were mild to moderate and did not significantly impact patient satisfaction.

Statistical analysis showed a moderate effect size for the ZFRooV's advantage in the near vision (Cohen's  $d = 0.5$ ). No significant differences were observed in distance or intermediate visual acuities<sup>(18)</sup>. Photic phenomena were statistically comparable, suggesting these effects

**Table 1.** Postoperative binocular assessment for UDVA in both groups

Binocular UDVA (logMar)	Panoptix n (%)	Synergy n (%)
-0.1	2 (18.2)	2 (25)
0.0	8 (72.7)	5 (62.5)
0.1	1 (9.1)	1 (12.5)
Total	11 (100)	8 (100)

UDVA: uncorrected distance visual acuity.

**Table 2.** Visual acuity and vision disturbances in both groups after surgery

	Synergy	Panoptix	Non-inferiority p-value
Visual acuity 30 cm			
0.1	8 (100)	9 (81.8)	1,000*
0.2	0 (0)	2 (18.2)	
Visual acuity 40 cm			
0.1	8 (100)	10 (90.9)	1.000*
0.2	0 (0)	1 (9.1)	
Visual acuity 60 cm			
0.1	4 (50.0)	6 (54.5)	0.609†
0.2	3 (37.5)	4 (36.4)	
0.3	1 (12.5)	1 (9.1)	
Photopic	3.21 ± 0.53	3.53 ± 0.85	0.592‡
Mesopic	4.69 ± 0.86	4.99 ± 1.12	0.170‡
Glare			
No	2 (25)	5 (45.4)	0.626†
Moderate	6 (75)	4 (36.4)	
Severe	0 (0)	2 (18.2)	
Daytime halo			
No	4 (50)	7 (63.6)	0.665†
Lightweight	4 (50)	3 (27.3)	
Moderate	0 (0)	1 (9.1)	
Nocturnal halo			
No	0 (0)	3 (27.3)	0.666†
Lightweight	4 (50.0)	3 (27.3)	
Moderate	3 (37.5)	2 (18.2)	
Severe	1 (12.5)	3 (27.3)	

\* Fisher's exact test; † Mann-Whitney test; ‡ Student's t-test for independent samples. Results expressed as n (%) or mean ± standard deviation.

**Table 3.** Monocular defocus curve in the dominant eye

Defocus	Visual acuity		Non inferiority p-value*	p-value*	Cohen D	Coefficient of a linear model (CI95%)	p-value
	SYNERGY Mean(SD)	PANOPTIX Mean(SD)					
-3	0.063 (0.092)	0.209 (0.138)	0.994	0.013	0.639	-0.052 (-0.089;-0.016)	0,005
-2.5	-0.013 (0.083)	0.100 (0.100)	0.992	0.017	0.612		
-2	0.013 (0.064)	0.091 (0.094)	0.977	0.046	0.494		
-1.5	0,038 (0,106)	0.145 (0,082)	0.984	0,032	0,551		
-1	0.175 (0.089)	0,200 (0.141)	0.679	0.643	0.108		
-0.5	0.100 (0.093)	0.091 (0.104)	0.422	0.844	-0.046		
0	-0.063 (0.052)	-0.027 (0.047)	0.926	0.149	0.350		
0.5	0.050 (0.107)	0.082 (0.125)	0.720	0.559	0.137		
1	0.238 (0.092)	0.273 (0.156)	0.728	0.545	0.142		
1,5	0.463 (0.092)	0.436 (0.242)	0.374	0.748	-0.075		
2	0.600 (0.160)	0.636 (0.291)	0.634	0.732	0.080		

\* Student test.

CI95%: confidence of 95% interval.

**Table 4.** Halos and glare in both groups

	Photopic		p-value	Mesopic		p-value
	SYNERGY Spearman's correlation (p-value)	PANOPTIX Spearman's correlation (p-value)		SYNERGY Spearman's correlation (p-value)	PANOPTIX Spearman's correlation (p-value)	
Glare	-0.13 (0.766)	0.04 (0.914)	0.962	-0.57 (0.140)	-0.03 (0.942)	0.349
Diurnal Halos	0.65 (0.078)	0.04 (0.917)	0.601			
Nocturnal Halos				-0.21 (0.618)	0.11 (0.770)	0.417

are characteristic of trifocal designs rather than specific lenses. Tables 1-4 summarize the IOL's results.

## DISCUSSION

Recently, new presbyopia IOLs have been introduced to improve postoperative outcomes following cataract surgery. Our findings suggest that the two lenses studied can achieve good postoperative distance, intermediate, and near objective and subjective outcomes. Objectively, the defocus curve exhibited similar performance for both IOLs, except in the myopic defocus, where the ZFRooV IOL was superior. Additionally, there was a trend for better performance of the ZFRooV IOL at near and intermediate distances.

Although most studies analyze monocular visual acuities, we decided to report binocular near and intermediate vision to mimic real-life conditions. In this study, previous studies evaluated the refractive outcomes of several trifocal IOLs, including the ZFRooV and TNFToo. Similarly to our study, they did not find statistically significant differences between groups in distance, near, and intermediate visual acuities. However, it was also noted that the ZFRooV tended to provide a broader functional range of focus, which may be advantageous for patients engaged in activities that require flexible focus at varying distances.<sup>(8)</sup>

The analysis shows that the ZFRooV IOL demonstrated consistent postoperative visual acuity, particularly at near distances. The ZFRooV group exhibited a mean UDVA of 0.0375 logMAR with a standard deviation of

0.0496, indicating stable distance vision. The mean values of UNVA at 30 cm and 40 cm were consistent at 0.1 logMAR with no variability (standard deviation [SD] = 0), underscoring reliable near vision. The UIVA at 60 cm presented a mean of 0.1625 logMAR with an SD of 0.0625, suggesting slight variability but overall satisfactory intermediate vision. While both IOLs offered good visual outcomes, the data did not indicate a statistically significant advantage for the TNFT00 IOL regarding UDVA or uncorrected intermediate visual acuity (UIVA). As initially mentioned, it did not explicitly show a flatter defocus curve in the distance and intermediate regions. Instead, the findings reflect that both lenses have their strengths, with ZFR00V providing a more continuous near vision and TNFT00 maintaining effective intermediate and distance performance.<sup>(4,10-14)</sup>

Defocus curves offer a graphical representation of visual acuity across different focus levels, allowing assessment of how effectively IOLs provide clear vision at various distances. Studies by Moshirfar et al.<sup>(4,11)</sup> and Dick et al.<sup>(15)</sup> determined superior visual acuity with the ZFR00V IOL compared to the TNFT00 IOL at near distance, particularly at the -3.5 D and -4.0 D defocus but determined improved distance and intermediate vision with the TNFT00 IOL. Other studies showed the superiority of the TNFT00 compared to other trifocal IOLs; this study's defocus curves are comparable to those previously published but did not show the superiority of one IOL over the other, except in the myopic defocus curves for the ZFR00V IOL.<sup>(2,3,6-9,11-19)</sup> The clinical results obtained in our defocus curve for the ZFR00V lens were also compatible with previous studies on the same lens, demonstrating good continuous UDVA, UNVA, and UIVA.<sup>(4,10,11,18-27)</sup>

Our study also demonstrated a better visual performance between the -1.5 and the -3.0D defocus obtained using the dominant eye, suggesting improved vision with the ZFR00V IOL at intermediate and near distances. However, assessment of near and intermediate binocular vision (a normal condition in real life) showed no statistical difference, suggesting that these results may not represent a real-world setting. Our study also indicates that ZFR00V provides enhanced near-visual acuity and a broader defocus curve for closer distances, making it advantageous for patients prioritizing near vision. Although both IOLs showed good intermediate and distance vision, no significant statistical advantage was observed for the TNFT00 lens in early postoperative assessments.

Despite dysphotopsias, most patients in our study were still willing to undergo surgery again with the same

IOL, likely because of good visual acuity at all distances and increased spectacle independence. In fact, for most of our patients, these symptoms did not significantly interfere with daily activities, which resulted in an improved quality of life (QoL). Therefore, IOL selection should consider not only each patient's specific visual needs but also one's tolerance for potential night-time visual disturbance.<sup>(4,10,11,14-16)</sup>

Furthermore, postoperative visual satisfaction depended on uncorrected VA at all distances and the lens's appropriateness for each patient's lifestyle and daily activities. The final assessment of each patient may involve influencing factors, such as the expectation of surgical results, type of professional occupation, daily routine activities, and patient's personality or critical sense. We observed that more patients in the TNFT00 group were satisfied and willing to undergo surgery again, suggesting that this IOL would suit a broader range of patients.

Subjective postoperative satisfaction was assessed, but no direct comparison with preoperative UCVA was made.

The study's limitations include the small sample size since it is a case series and binocular visual acuity measurements. Although one may find it difficult to draw conclusions from a small study, we did observe some superiority of the ZFR00V IOL on the monocular defocus curve. Additionally, we aimed to reproduce a real-life setting in which patients use both eyes. We might have seen more differences between these IOLs had we included a larger sample size.

In conclusion, when assessed binocularly, ZFR00V and TNFT00 IOLs offer comparable visual outcomes for far, near, and intermediate distances. This study demonstrated the advantage of the ZFR00V in the monocular defocus curve for near vision.

## Value statement

### What was known

- Trifocal IOLs provide spectacle independence by enhancing vision at near, intermediate, and distance ranges.
- The ZFR00V and TNFT00 IOLs have different optical designs, each aiming to optimize visual performance across varying distances.
- Prior studies suggested that ZFR00V may offer better near vision, while TNFT00 may provide superior intermediate vision.

## What this paper adds

- A real-world comparison of ZFRooV and TNFToo IOLs in a clinical setting, analyzing both objective and subjective outcomes.
- There is evidence that the ZFRooV IOL provides superior near vision in the monocular defocus curve, while both lenses offer similar binocular performance.
- Confirmation that photic phenomena are common in both lenses but do not significantly affect patient satisfaction, emphasizing the importance of patient-specific IOL selection.

## DECLARATIONS

This paper has been uploaded to Research Square as a preprint: <https://www.researchsquare.com/article/rs-4293746/v1>

## AUTHORS' CONTRIBUTION

Substantial contribution to conception and design: Maria Carolina Zanata, César Vilar, Bernardo Kaplan Moscovici, Patrick Frensel de Moraes Tzelikis, Paulo Tadeu Silva Campos, André Lins de Medeiros, Larissa Gouvea, Wilson Takashi Hida; Acquisition of data: Maria Carolina Zanata, Mario Augusto Pereira Dias Chaves, Jonathan Clive Lake, Maurício Agne Newald, Antônio Francisco Pimenta Motta, Pedro Carlos Carricondo; Analysis and interpretation of data: Maria Carolina Zanata, César Vilar, Bernardo Kaplan Moscovici, Patrick Frensel de Moraes Tzelikis, Paulo Tadeu Silva Campos, André Lins de Medeiros, Larissa Gouvea, Wilson Takashi Hida; Drafting of the manuscript: Maria Carolina Zanata, César Vilar, Bernardo Kaplan Moscovici, Mario Augusto Pereira Dias Chaves, Jonathan Clive Lake, Maurício Agne Newald, Antônio Francisco Pimenta Motta, Pedro Carlos Carricondo, Wilson Takashi Hida; Critical revision of the manuscript for important intellectual content: Maria Carolina Zanata, Bernardo Kaplan Moscovici, Patrick Frensel de Moraes Tzelikis, Paulo Tadeu Silva Campos, André Lins de Medeiros, Larissa Gouvea, Wilson Takashi Hida; Statistical analysis: Maria Carolina Zanata, César Vilar, Bernardo Kaplan Moscovici, Mario Augusto Pereira Dias Chaves, Jonathan Clive Lake, Maurício Agne Newald, Antônio Francisco Pimenta Motta, Pedro Carlos Carricondo, Wilson Takashi Hida; Administrative, technical, or material support supervision: Maria Carolina Zanata, Bernardo Kaplan Moscovici, Mario Augusto Pereira Dias Chaves, Patrick Frensel de Moraes Tzelikis, Paulo Tadeu Silva Campos, André Lins de Medeiros, Larissa Gouvea, Wilson Takashi Hida; Research group leadership: Maria Carolina Zanata, César

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