Objective Metrics for Quantifying Monofocal and Presbyopia-Correcting IOL Contrast Performance

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Disclosures

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Abstract: 84997

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Purpose

The purpose of this study is to evaluate the objective metrics for quantifying monofocal and presbyopia-correcting IOL contrast performance in both day and night conditions.

- With increasing age, decreasing contrast sensitivity may impact patient safety.[1-3]
- Study results highlight a previously unappreciated association between older adults' mesopic contrast sensitivity deficits and crash involvement regardless of the time of day.[3]
- This puts the emphasis on the contrast performance of IOLs for larger pupil sizes.

1. Black, A., & Wood, J. (2005). Vision and falls. Clin Exp Optom, 88 (4), 212-222.
2. Feng, Y.R., Meuleners, L., Stevenson, M., Heyworth, J., Murray, K., Fraser, M., & Maher, S. (2021). Driving exposure, patterns and safety critical events for older drivers with and without mild cognitive impairment: Findings from a naturalistic driving study. Accid Anal Prev, 151, 105965.
3. Owsley, C., Swain, T., Liu, R., McGwin, G., Jr., & Kwon, M.Y. (2020). Association of Photopic and Mesopic Contrast Sensitivity in older drivers with risk of motor vehicle collision using naturalistic driving data. BMC Ophthalmol, 20 (1), 47.

Methods

- Modulation transfer function (MTF) was measured under clinically relevant conditions.[1]
- Through focus and frequency MTF was measured in white light for 3mm pupil in an eye model that reproduces average corneal spherical and corneal chromatic aberrations.[1,2]
- MTF at both 3mm (photopic) and 5mm (mesopic) pupil diameters were recorded.
- IOL models included in this study were:

  Tecnis 1-Piece, Tecnis Eyhance, and Acrysof IQ monofocal IOLs

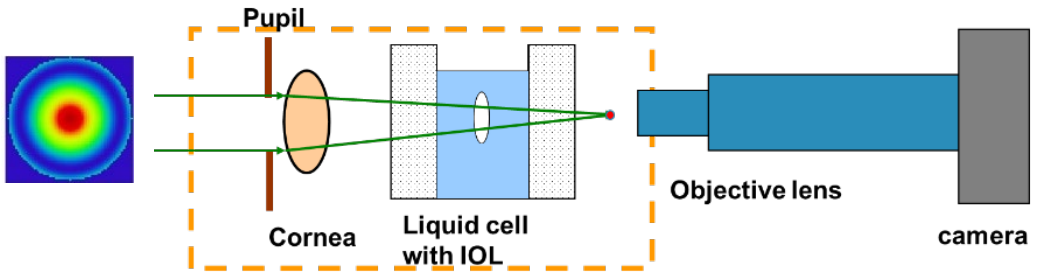
  Tecnis Symfony Optiblue and Acrysof Vivity EDOF IOLs

  Tecnis Multifocal +3.25, Acrysof Restor +3.0, Acrysof Panoptix multi/trifocal IOLs, and Tecnis Synergy IOLs

1. Weeber HA, Cánovas C, Alarcón A, Piers P. (2016). Laboratory-Measured MTF of IOLs and Clinical Performance. *J. Refract. Surg*. 32(3), 211–212.
2. Norrby S, Piers P, Campbell C, van der Mooren M. (2007). Model eyes for evaluation of intraocular lenses. *Appl Opt* 46:6595– 6605.

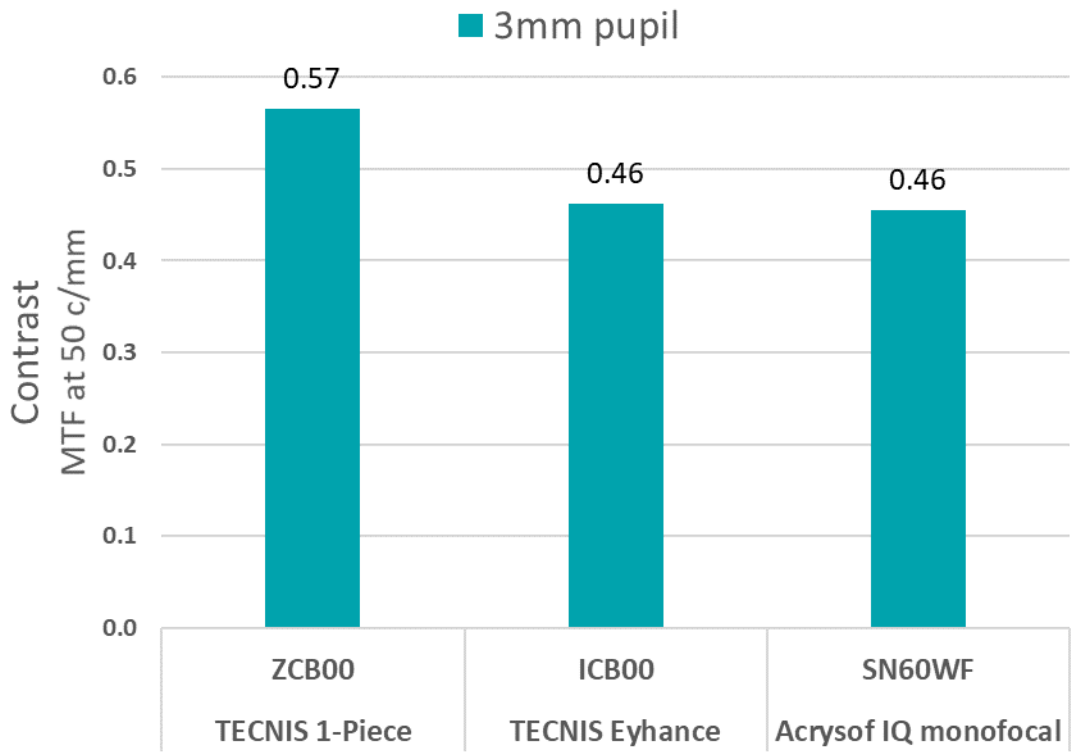
Modulation transfer function (MTF) is a measure of the contrast of the image in the eye.

In a pre-clinical setting, it is the measure of contrast of the image of a model eye containing the IOL under test.

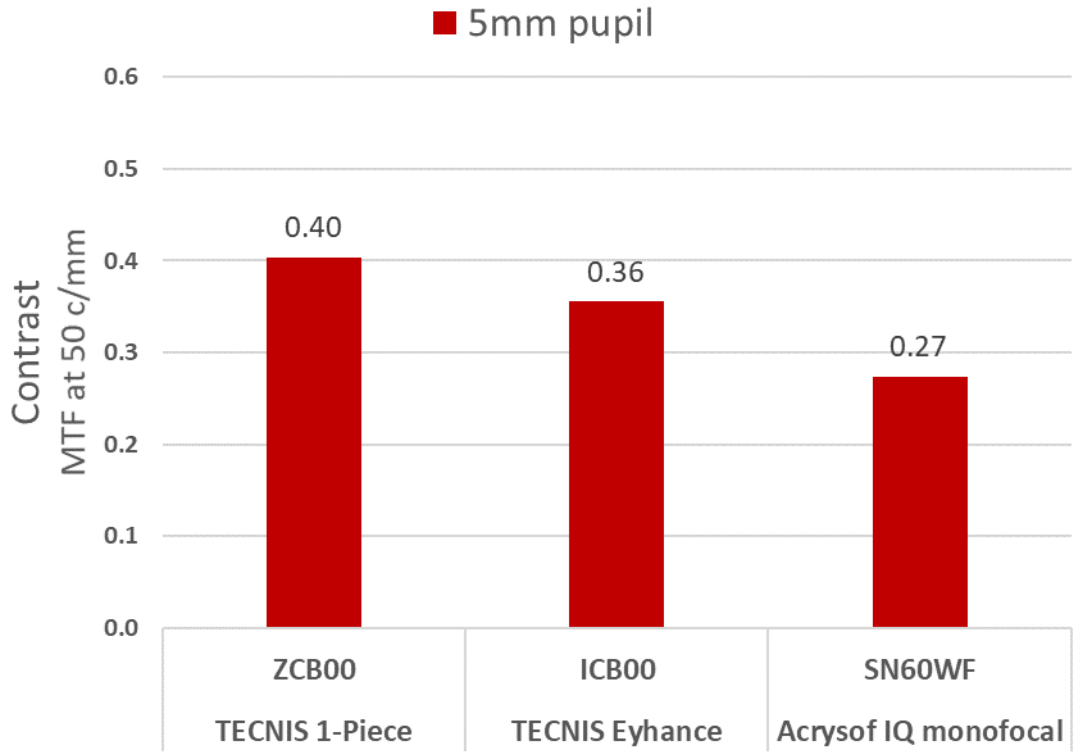


Results

Measured image contrast of monofocal IOLs



Photopic (small pupil) MTF varies by lens model.
Highest and lowest MTF differ by a factor 1.2X.

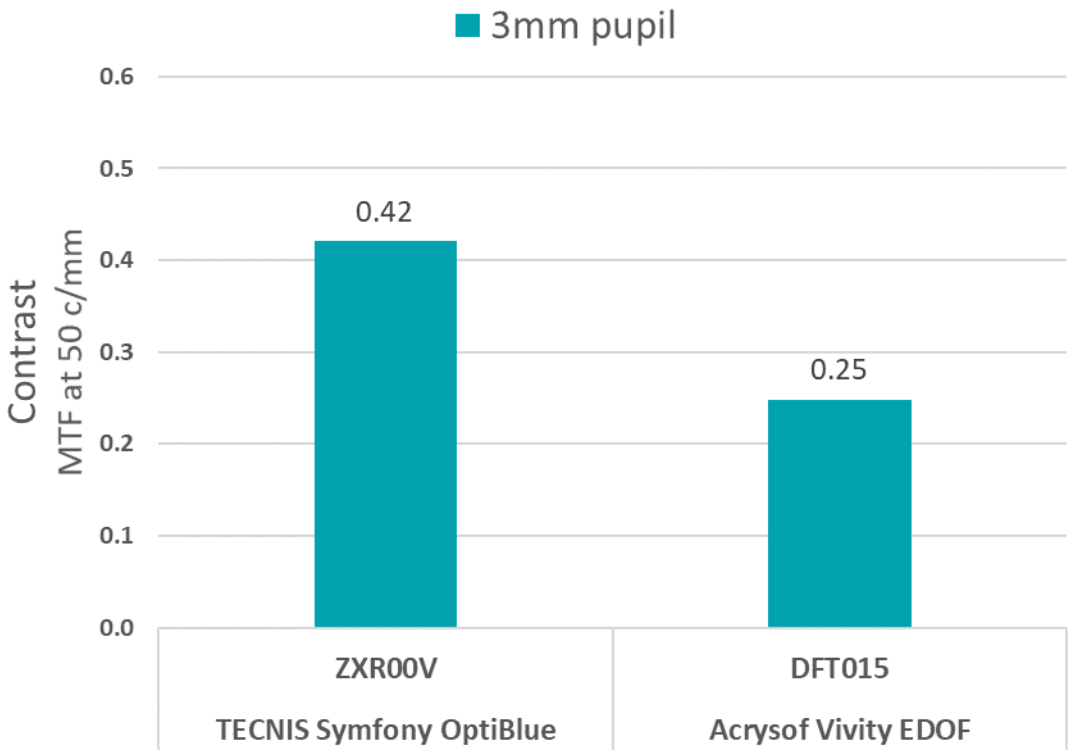


Mesopic (large pupil) MTF varies greatly by lens model.
Highest and lowest MTF differ by a factor 1.5X.

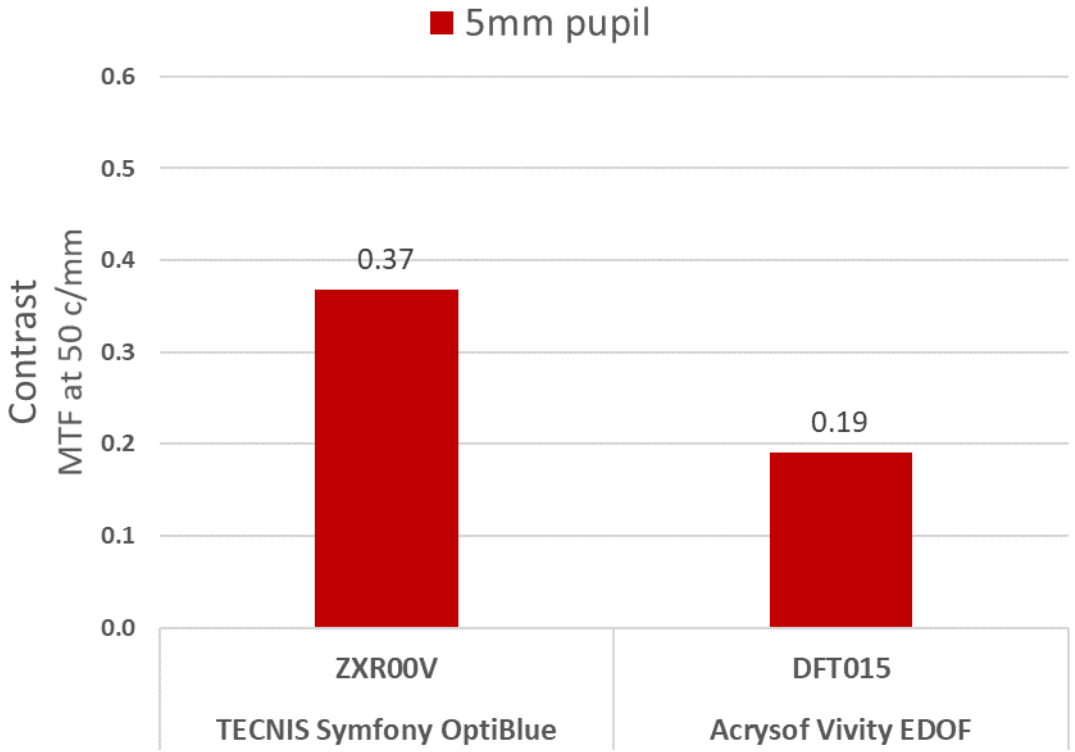
taller bars = better contrast

Results

Measured image contrast of EDOF IOLs



Photopic (small pupil) MTF varies greatly by lens model.
Highest and lowest MTF differ by a factor 1.7X.

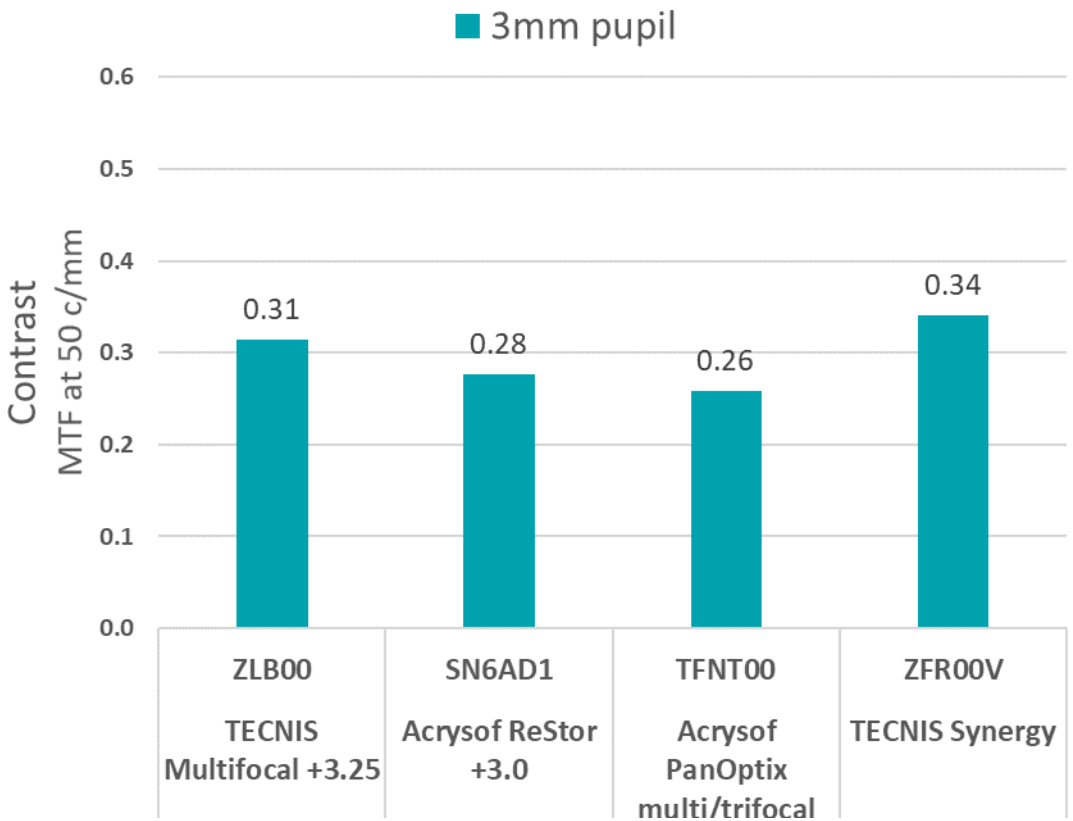


Mesopic (large pupil) MTF varies greatly by lens model.
Highest and lowest MTF differ by a factor 1.9X.

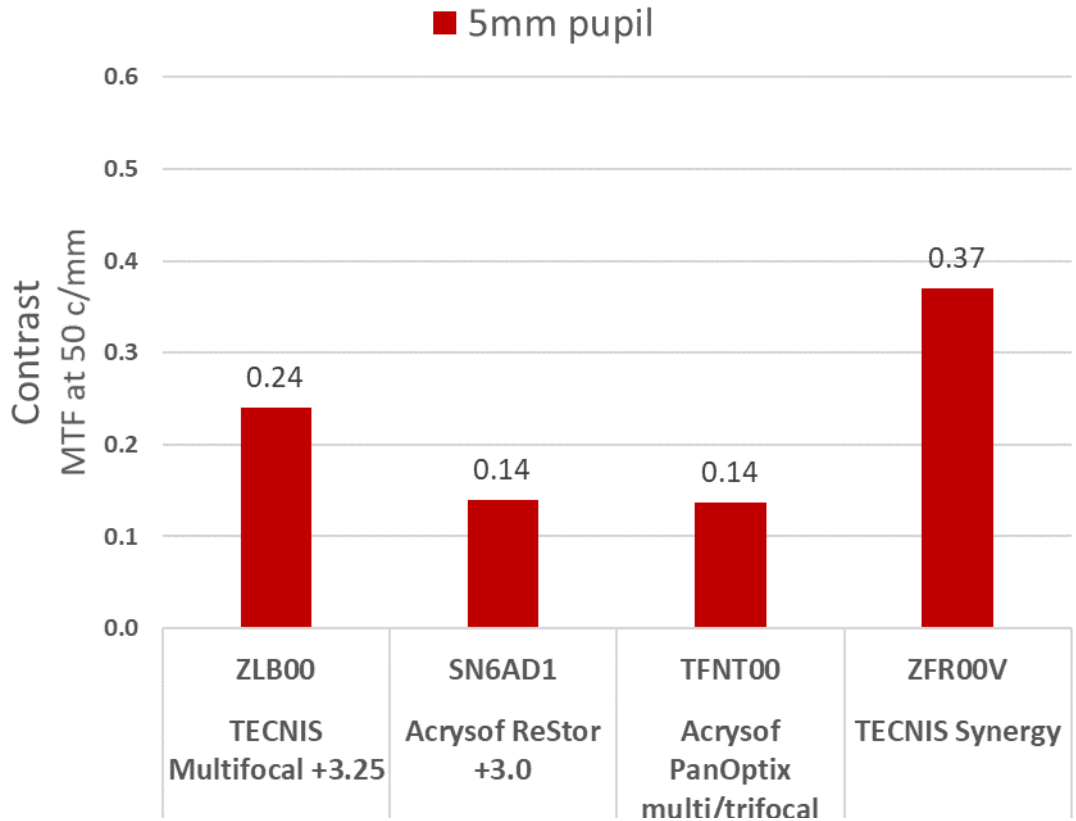
taller bars = better contrast

Results

Measured image contrast of PC IOLs



Photopic (small pupil) MTF varies by lens model.
Highest and lowest MTF differ by a factor 1.3X.



Mesopic (large pupil) MTF varies greatly by lens model.
Highest and lowest MTF differ by a factor 2.7X.

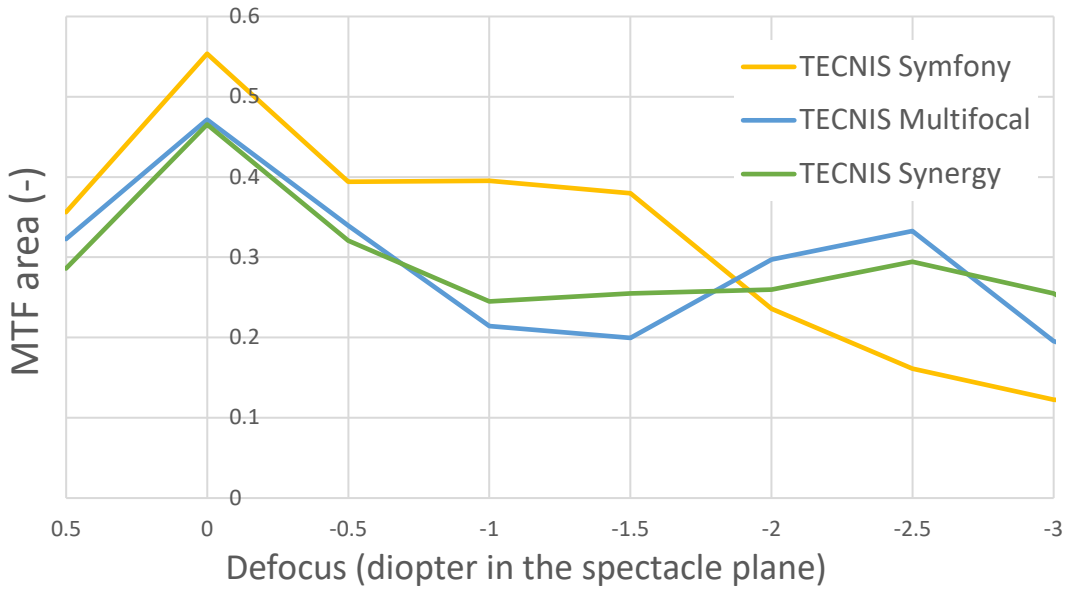
taller bars = better contrast

Results

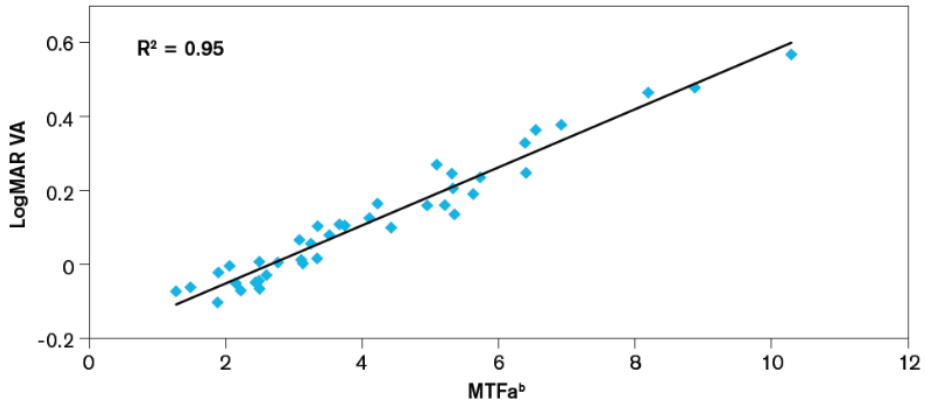
Combining a *range* of spatial frequencies

- MTF over a range of spatial frequencies are integrated to create the area under the MTF curve (MTFarea or MTFa).
- MTFa through 50 cycles per mm has shown a consistent correlation to visual acuity (VA) for a range of lens materials and designs.[1]

Defocus curve of MTFarea, showing the differences between a bifocal lens, an extended depth of focus lens, and a PC lens combining both technologies



Correlation between optical bench and clinical VA[1]

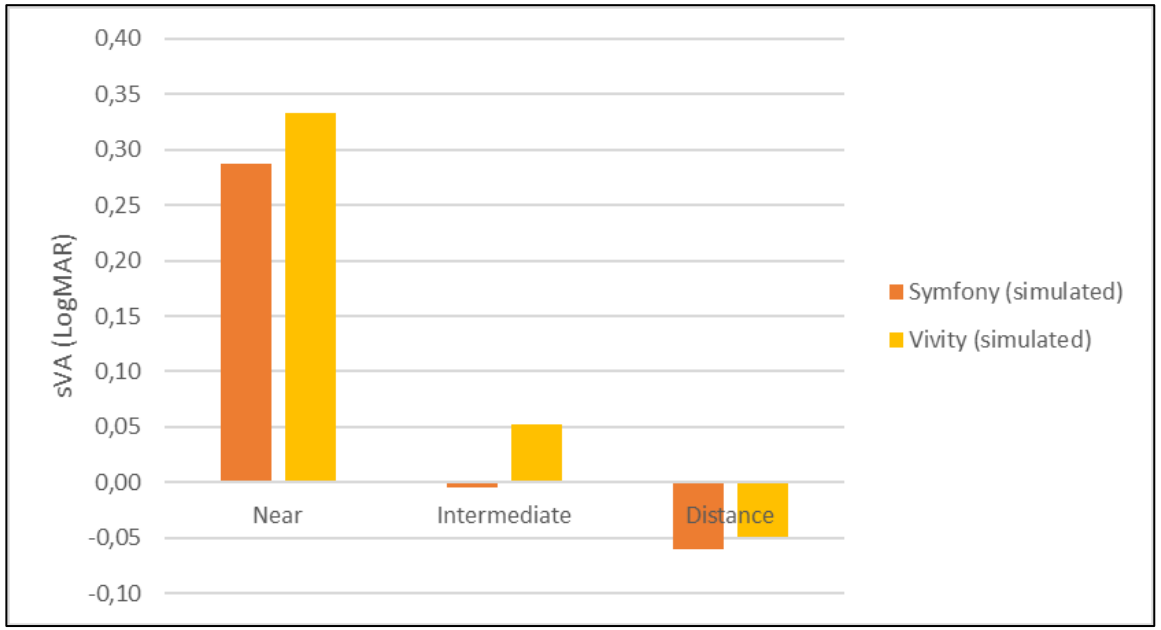


1. Alarcon, A., Canovas, C., Rosen, R., Weeber, H., Tsai, L., Hileman, K., & Piers, P. (2016). Preclinical metrics to predict through-focus visual acuity for pseudophakic patients. *Biomedical optics express*, *7*(5), 1877-1888.

Results

TECNIS Symfony vs Vivity

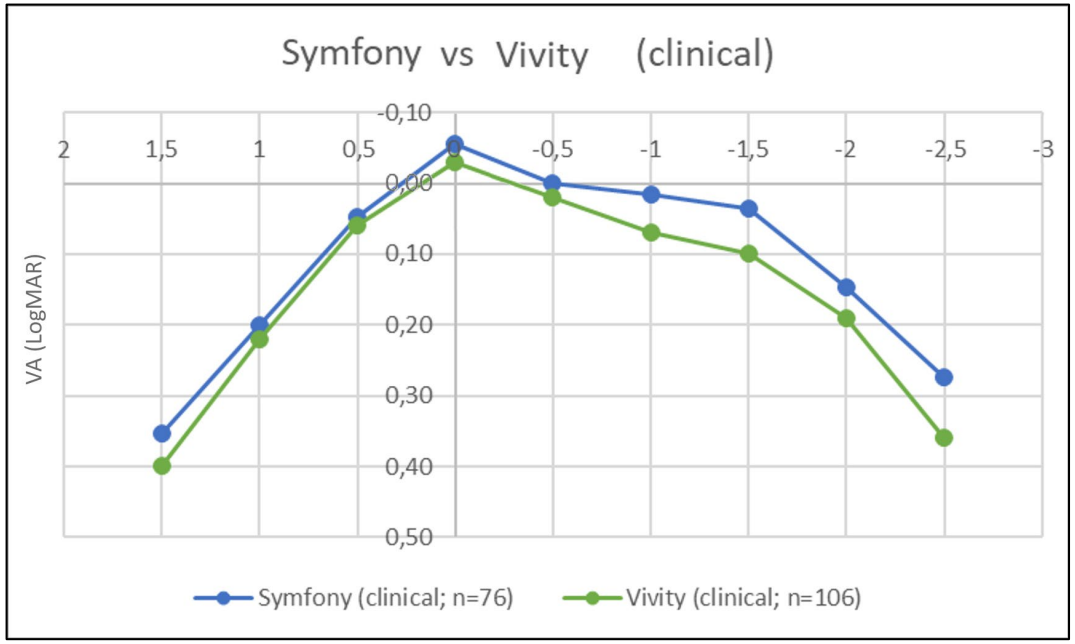
Simulated Visual Acuity (sVA)



Simulated visual acuity (sVA) predicted: similar Far visual acuity. Intermediate and Near visual acuity of at least one-half line higher for TECNIS Symfony demonstrating a greater range of vision for this EDOF IOL.

More negative bars = better simulated VA

Clinical Visual Acuity [1]



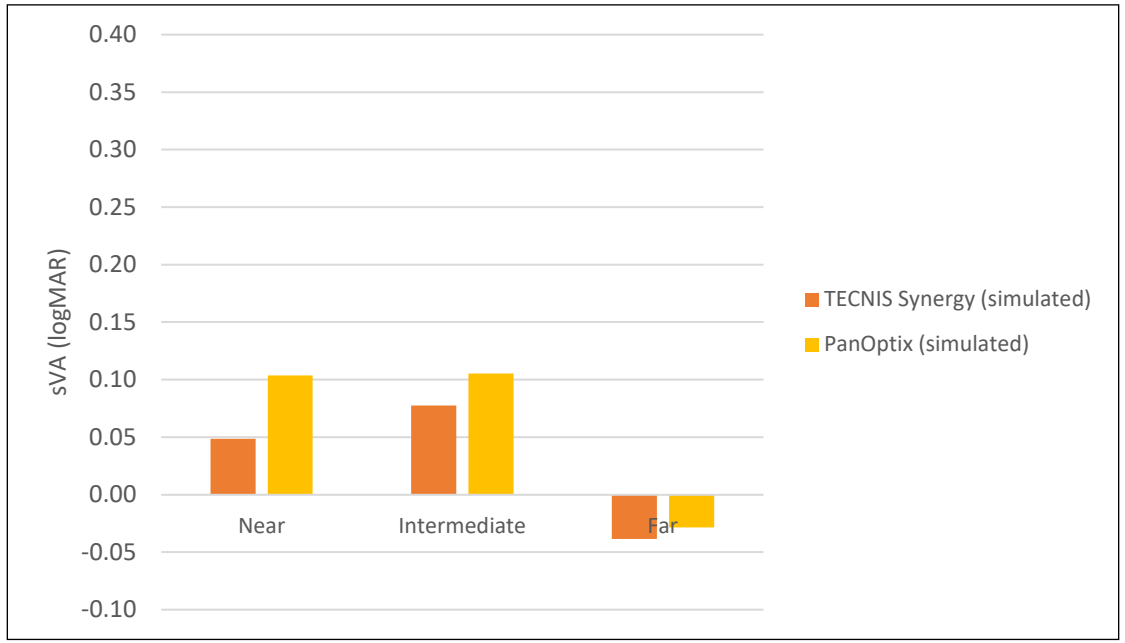
Clinical defocus curves revealed greater differences between both EDOF IOLs through the complete defocus curve, with more than half a line improvement at intermediate and one line at near for TECNIS Symfony.

1. Clinical data on file. DOF2020CT4012_Comparison of Vivity IOL defocus curve with Symfony IOL clinical data.

Results

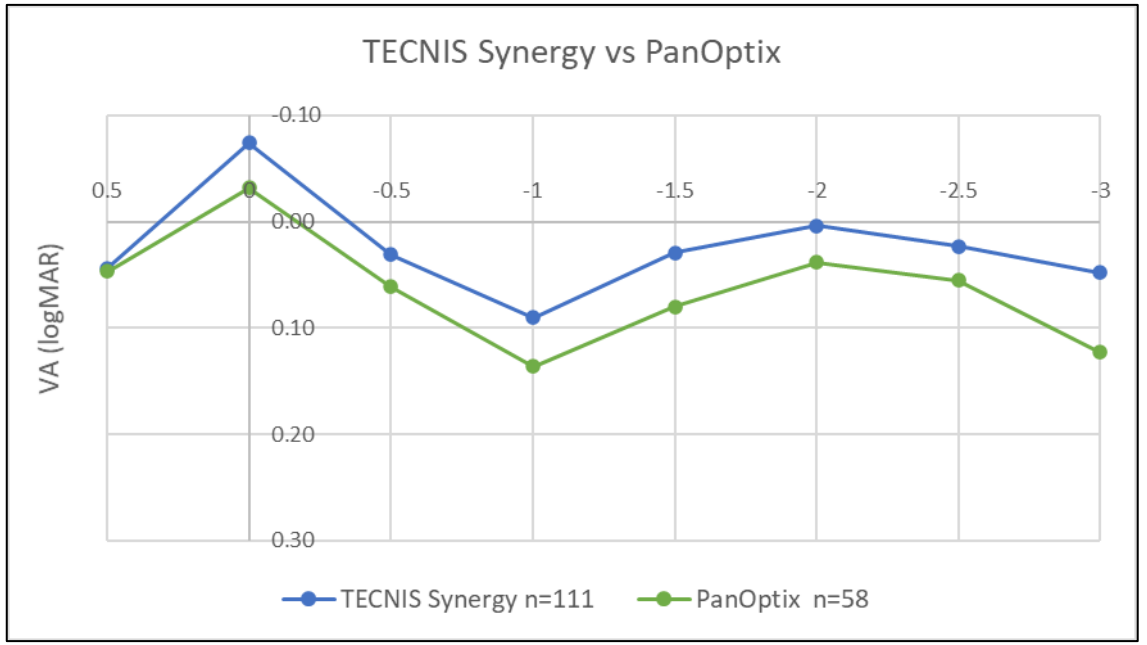
Visual acuity and defocus curves of presbyopia-correcting IOLs covering the full range of vision

Simulated Visual Acuity (sVA)



Simulated visual acuity (sVA) predicted visual acuities better for TECNIS Synergy at all distances, reaching one-half line at near demonstrating in a greater range of vision for this IOL.

Clinical Visual Acuity[1]



Clinical defocus curves revealed a consistent difference between both PC IOLs throughout the complete defocus curve, with approximately half a line improvement for TECNIS Synergy.

More negative bars = better simulated VA

1. Clinical data on file: DOF2020CT4014. – Forte 1 Study: A comparative clinical evaluation of a new TECNIS PCIOL against PanOptix® IOL.

Conclusions

- MTF (contrast) was measured over a range of defocus values, over a range of frequencies, for various pupil sizes, and for three categories of IOLs: monofocal IOLs, EDOF IOLs, and presbyopia-correcting IOLs covering the full range of vision.
- MTF varied widely between the different lens models, especially for the larger pupil sizes (mesopic conditions).
- Within categories, the presbyopia-correcting IOL with the highest MTF showed a value 2.7 times greater than that of the presbyopia-correcting IOL having the lowest MTF.
- MTFarea (MTFa) provides a robust method for evaluating IOL performance and contrast over a range of defocus for monofocal IOLs, EDOF IOLs, and presbyopia-correcting IOLs covering the full range of vision.
- EDOF IOLs and presbyopia-correcting IOLs covering the full range of vision can exhibit differences of up to a line in simulated VA and half a line in clinical defocus curve testing.