Defocus Curves and Wavefront Sensing for a Universal Add

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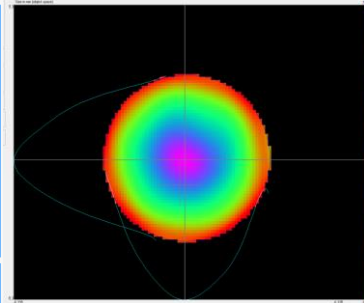*Visioneering Technologies, Inc., ^Wavefront Dynamics, Inc.

Purpose: Employing relative plus power to extend the functional vision range is a primary method to correct presbyopia with contact lenses. This study evaluated the optical characteristics and visual performance of a unique contact lens designed[1] with a catenary[2] curve-based extended depth of focus (EDOF) optical profile on mature presbyopes' functional vision.

Methods: A Hartmann-Shack wavefront sensor with 108 um sampling was used to characterize the catenary optical profile. Presbyopes with Add requirements of +2.00 D or more were recruited for this prospective study. Following the fitting guide for the study lens, the refractive endpoint is biased to the green using the Duochrome test binocularly in a dark room. Repeated monocular and binocular visual acuities were obtained using (1) best distance-corrected single vision spectacle lenses (Baseline) followed by (2) the study lenses (Neurofocus), as a series of loose lenses ranging from -4.00 D to +2.00 D in 0.50 D increments were imposed. LogMAR high contrast visual acuity with each lens and test condition were used to generate defocus curves (the clinical standard to evaluate the performance of the EDOF class of ophthalmic optics), which were compared to one another for statistical significance.
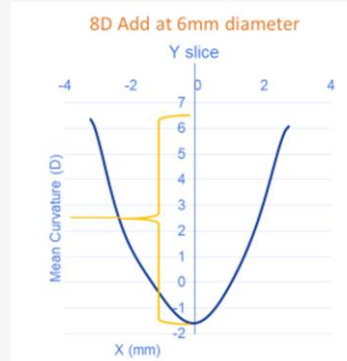
Results: Wavefront measurement revealed a smooth and rapid power progression that can be decomposed into a high magnitude of spherical aberrations, resulting in an elongated depth of focus. 24 subjects (age 50+; Adds of $\geq$ +2.00 D, and astigmatism $\leq$ 1.00 D) completed the defocus curve measurements.

References:
1. Patents Awarded – MULTIFOCAL OPHTHALMIC LENS WITH INDUCED APERTURE. See https://vtivision.com/about/patents/ for patent numbers.
2. Wikipedia. Accessed November 2022, from https://en.wikipedia.org/wiki/Catenary

**Hartmann-Shack aberrometer**

8D Add at 6mm diameter

Results: Average pupil size of subjects was 3.61mm (2.3 to 5.1) under high illumination. The pupil size of subject's right eye was compared with monocular logMAR vision from the right eye at -2.00 D, -2.50 D, and -3.00 D defocus. Regression analysis shown no correlations between pupil size and near logMAR vision (R^2= 0.0033, 0.0163, and 0.0247 respectively). Monocularly, subjects demonstrated statistically significant improvement (p<0.05) in visual acuity while wearing the study lens from -1.00 D through -4.00 D defocus (equivalent to object distances from 1 meter to 25 cm), whereas no statistically significant difference was observed with the -0.50 D through +2.00 D defocus (equivalent to object distances of 2 meters and beyond).
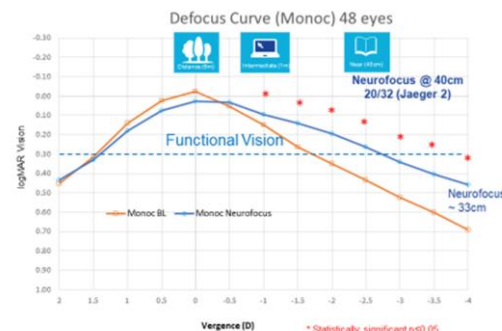
BL = Baseline[2]: Best Distance Corrected Spectacle Vision
Neurofocus improves Intermediate and near vision without significant reduction in distance vision

Results: Binocularly, subjects demonstrated statistically significant improvement (p<0.05) in visual acuity while wearing the study lens from -1.50 D through -4.00 D defocus (equivalent to object distances from 66 cm to 25 cm), whereas no statistically significant difference was observed with the -1.00 D through +2.00 D defocus (equivalent to object distances of 1 meter and beyond).
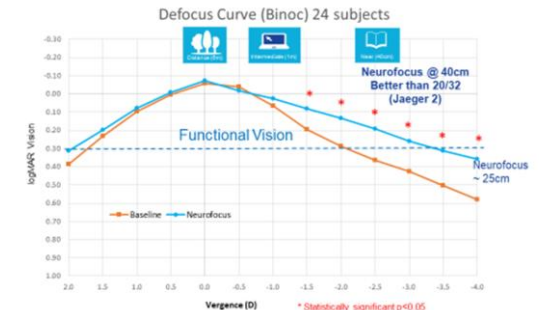
Baseline: Best Distance Corrected Spectacle Vision
Neurofocus improves Intermediate and near vision without significant reduction in distance vision

Results: Compared to baseline data, the range of Depth of Focus was extended by 2 diopters with the study lenses, while distance and intermediate vision were maintained at 20/20 or better.

Conclusion: Instead of pushing plus to avoid prescribing high Add power, the catenary curve-based study lenses, fitted with a bias toward minus, provided a full range of functional vision (20/40 or better) through up to 3.50 D optical vergence demand while maintaining clear distance vision for mature presbyopes. Study results demonstrated, due to the quality of distance vision, this Extended Depth of Focus lens design may provide a universal Add for the full spectrum of Add requirements.

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