ASSESSING CHILDREN'S GAZE DIRECTION WITH ASYMMETRIC MYOPIC DEFOCUS LENSES VIA EYE-TRACKING

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INTRODUCTION

Asymmetric Myopic Peripheral Defocus Lenses (MPDL) feature a central 7 mm oval, blur-free zone and an asymmetrical myopic defocus: +1.50 D nasally and +1.80 D temporally at 25 mm, and +2.00 D inferior zone (figure 1). Recent studies in a Spanish pediatric population have demonstrated that MPDL reduced axial length growth by 39% at 12 months[1] and 29% at 24 months[2] compared to single vision lenses (SVL).

While the effectiveness of myopia control treatments has been well studied, little research has been conducted on how children use ophthalmic lenses designed for this purpose. This study uses eye-tracking technology to assess pupil position and gaze behavior at different viewing distances in children wearing MPDL or SVL during various visual condition. By analyzing heatmaps and calculating the lens usage area, this study aims to provide new insights into how MPDL affect children's visual strategies and their potential impact on myopia progression.

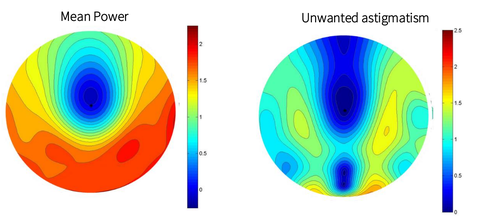

Figure 1: Spherical equivalent and cylinder power distribution maps for a plano prescription of the MPDL lens.

PURPOSE: The goal is to analyze children's gaze positions when using Asymmetric Myopic Peripheral Defocus Lenses (MPDL) compared to standard Single Vision Lenses (SVL).

METHODS

Study design: Double-blind comparative study in a sample of myopic children.

Sample: 22 children, aged 7-15 years old, who met the following inclusion criteria: 1) Cycloplegic spherical equivalent ≤ -0.50; 2) Astigmatism < 1.50 D; 3) Anisometropia < 1.50 D; 4) Visual Acuity ≥ 20/20; 5) Users during, at least, one month, of MPDL as unique myopia treatment.

Procedure: Participants were asked to recognize a single Sloan letter (size 0.4VA dec) displayed at different distances on a screen (figure 2) while their gaze direction was recorded using a wearable eye-tracker (Tobii-Pro Glasses 3).
Conditions:
- Distance: 85 inches screen at 3.73 m (16.5x28.5 deg)
- Intermediate: 32 inches screen at 0.80 m (21.6x35.0 deg)
- Near: Tablet at 0.40 m (26.7x36.1 deg)

Evaluted designs: two different lenses (index 1.6) where evaluated, attached to a metal frame to the eye-tracker:
- MPDL: MyoLess lens (IOT, Spain)
- SVL: Single Vision lens (IOT, Spain)

Experimental evaluation of region of use: The coordinates of each fixation on the lens were calculated with a previously developed[3,4] algorithm. From heatmaps of lens usage was determining the percentage of time spent in each lens region. The lens usage area was calculated as the convex hull of fixations during tasks, and the vertical region of use was defined as the vertical distance from the fixation mass center to the lens fitting cross (figure 3).

Statistical analysis: The use of MPDL and SVL for each condition was compared with t-test for paired samples. The analysis was done by Statgraphics Centurion XVI.II. Significance p<0.05*.

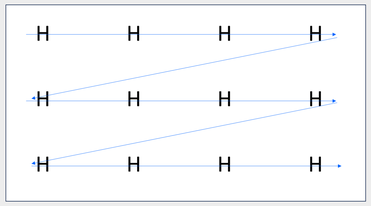

Figure 2: Visual task: A single letter is projected on the screen in position 1. After the subject answers, a different letter of the same size appear in the next position. Letter positions create a scanning pattern across the screen, testing 4 horizontal and 3 vertical positions

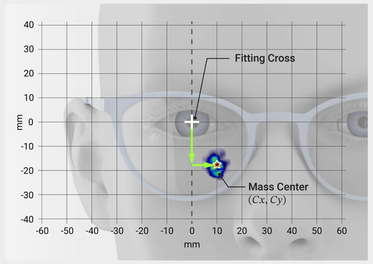

Figure 3: Diagram of the vertical and horizontal region of use for right eye looking at near-reading right side, considering the lens viewed from the front, the center of mass ((Cx,Cy), depicted by the star).

CONCLUSIONS: MPDL modifies children's gaze positions, especially for intermediate and near vision. Children tend to use the central lens area with lower myopic defocus for comfortable vision, while inducing peripheral myopic defocus to help reduce myopia progression. Future studies are needed to understand the relationship between children's gaze direction and treatment efficacy and/or comfort.

RESULTS

- Figure 4 shows an example of heatmaps of two subjects during the different tasks.
- With MPDL, time spent in lens areas with Addition <0.50D was 89%, 73%, and 33% for distance, intermediate, and near conditions, respectively. Time in zones with Addition >1.00D was 3%, 5%, and 34% (figure 5).
- Statistically significant differences in gaze direction were found between SVL and MPDL lenses (figure 6; table 1). When using MPDL, the lens usage area was narrower for all the distances, with statistically significant differences at intermediate distance; and the vertical pupil position tends to be less negative with respect SVL, with statistically significant differences for near distance.

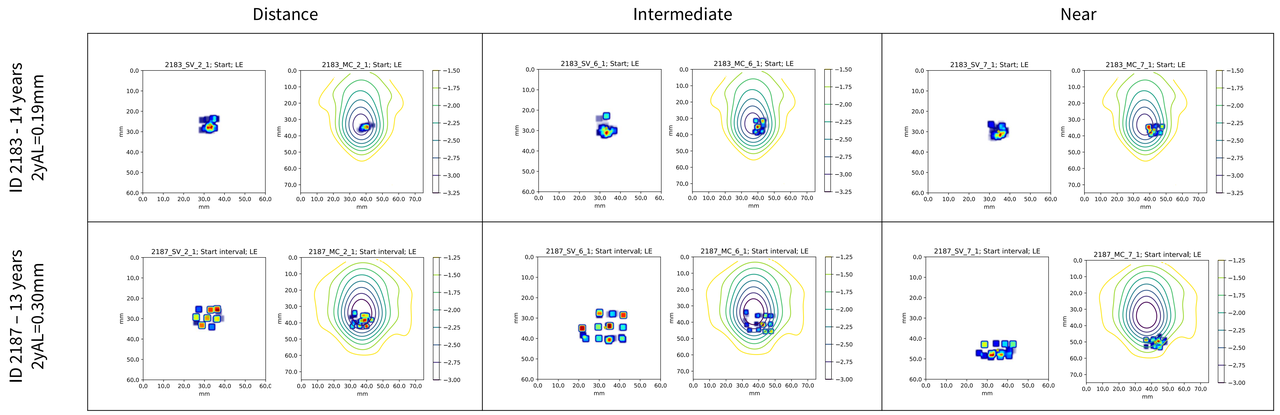

Figure 4: Heatmaps examples of different myopic children wearing the SVL and the MPDL for the task at distance, intermediate and near vision.

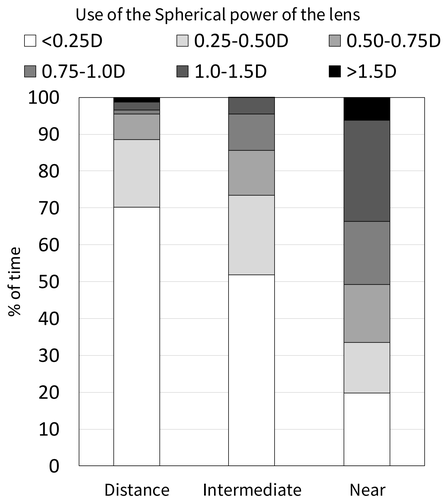

Figure 5: Averaged percentage of time that subject spend in each region of the MPDL during the different distances.

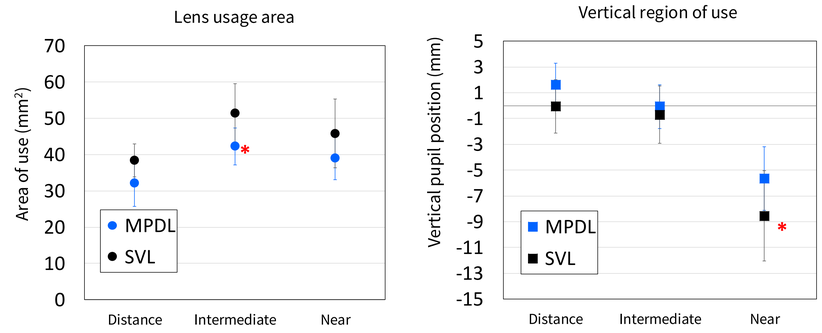

Figure 6: Averaged lens usage area (left) and the vertical region of use (right) when using SV

Working distance	Area of use of the lens			Vertical viewing position		
	MPDL	SV	p-value	MPDL	SV	p-value
Distance	32.1±6.4	38.4±4.5	**0.07**	1.6±1.7	-0.1±2.1	**0.11**
Intermediate	42.3±5.1	51.4±8.2	**0.01***	-0.1±1.7	-0.7±2.2	**0.38**
Near	39.1±6.0	45.9±9.4	**0.07**	-5.7±2.5	-8.5±3.5	**0.001***

Table 1: Statistical analysis of lens usage area (left) and the vertical region of use (right) when using SV

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