Consideration of Optical Scotomas in Designing Visual Field Expansion Devices

#4734

D1000

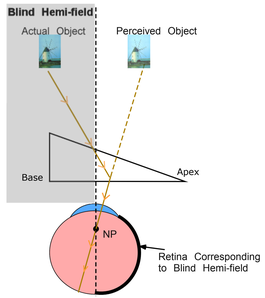
Nicole C. Ross[1,2], Alex R. Bowers[2], Eli Peli[2]

[1]New England College of Optometry, Boston, MA [2]Schepens Eye Research Institute, Dept. Ophthalmology, Harvard University Medical School, Boston, MA

Background

Prisms are used in rehabilitation of hemianopia to expand or relocate the visual field (VF).
In addition to shifting images to a functional part of the VF, they also create a scotoma at the prism apex.
This prism apical scotoma (PAS) could compromise areas of remaining vision.

Prism Shifts Image



Optical Scotoma Caused by Prism

No prism
Monocular view
Sign visible

With prism
Monocular view
Sign no longer visible

A simplified cylcopean view of a patient with Left hem. wearing a prism

Research Questions

1. **Does the prism apical scotoma (PAS) impact binocular viewing?**
2. **Can we predict the position of the PAS?**

Fitting Prisms for Hemianopia

Unilateral Segment Prism (Traditional Clinical Practice):

A prism segment is base-out on the side of the hemianopia.

Prism apex is placed a few mm into the blind hemi-field to avoid diplopia in primary gaze (Dickinson 1998).

Horizontal Peripheral Prisms (New Method):

Prisms are fit unilaterally 6 mm above and below pupil center, base out on the side of hemianopia.

Patients are instructed to look through the center clear, inter-prism area to avoid central diplopia (Peli 2000).

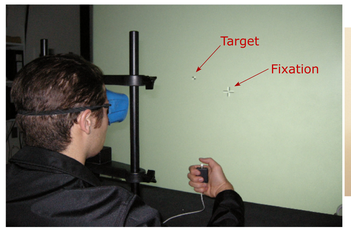
Oblique Peripheral Prisms (Expansion more central):

The upper segment is placed base down and base out on the side of the hemianopia while the lower segment is placed base up and base out.

See poster #4733, D999

Methods

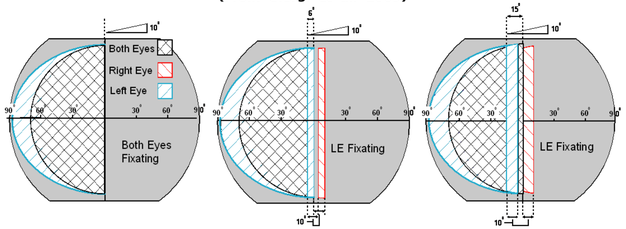
- Patients with homonymous hemianopia (n=4) wore habitual prism spectacles with unilateral prism segments (40Δ).
- Normal Vision subjects (n=4) also wore spectacles with unilateral 40Δ prism segments.
- We additionally measured visual fields on patients wearing 57Δ oblique, 57Δ horizontal and 16Δ unilateral segment prisms.
- Dichoptic presentation was used during perimetry to test each eye independently under binocular viewing conditions.
- PAS was mapped using a 16x16 mm (8x8 pixel) square bipolar target of 95% contrast at 1 m.



VF with Unilateral Sector Prism

R Hem, 16Δ base out unilateral segment prisms

Schematic Dichoptic VF Plots (From Giorgi et al. 2009)

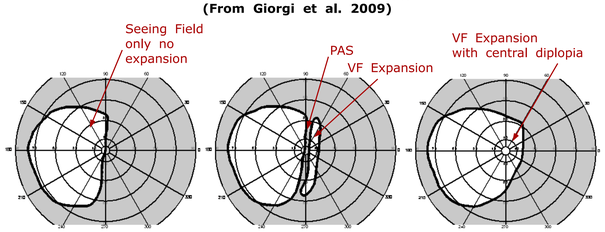


Looking in primary gaze
Eye not looking through prism
No expansion in binocular view

Looking slightly into prism
Eye turned 6° into prism
10° expansion from prism
PAS of 4° in binocular view

Looking further into prism
Eye turned 15° into prism
10° expansion from prism
No PAS in binocular view
but with central diplopia

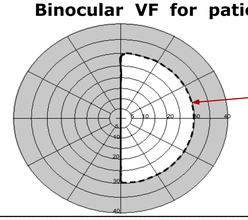
Binocular Goldmann VF Plots (From Giorgi et al. 2009)



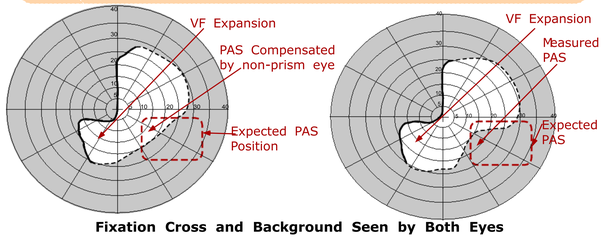
Looking in primary gaze | **Looking slightly into prism** | **Looking further into prism**

VF with Peripheral Prisms

Binocular VF for patient with L Hem.



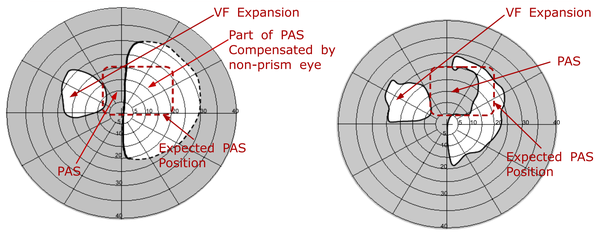
L Hem, 40Δ horizontal (base out) peripheral prism
Lower Prism Only Mapped



Fixation Cross and Background Seen by Both Eyes

Target to both eyes. | Target to the prism eye only

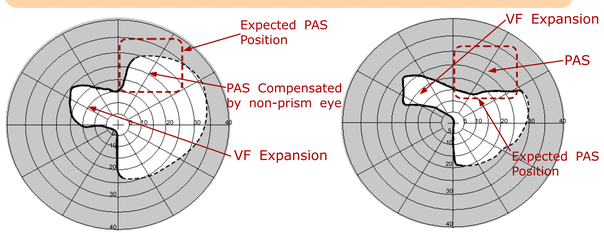
L Hem, 57Δ horizontal (base out) peripheral prism
Upper Prism Only Mapped



Fixation Cross and Background Seen by Both Eyes

Target to both eyes. | Target to the prism eye only

L Hem, 57Δ oblique peripheral prism
Upper Prism Only Mapped. (upper prism base @330°)



Fixation Cross and Background Seen by Both Eyes

Target to both eyes. | Target to the prism eye only
Note vertical shift in VF due to change in head position

Results

Does the Prism Apical Scotoma Impact Binocular Viewing?

- When the target was presented to both eyes no part of the PAS could be mapped for those wearing 40Δ horizontal prisms.
- However for subjects wearing 57Δ horizontal prisms part of the PAS was mapped in the binocular view.
- When the target was presented to the prism eye only a PAS was mapped for all subjects. This means that PAS would impact vision in bilateral fittings.

Can We Predict the Position of the Prism Apical Scotoma?

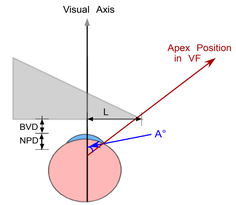
We compared correspondence between calculated and measured PAS start position and lateral extent for subjects wearing 40Δ horizontal prisms.

Calculating PAS Lateral Extent (LEX)

$$LEX = \tan^{-1}\left(\frac{P}{100}\cos(\phi)\right)$$

Where: P= prism power (Δ)
ϕ = angle of tilt

Calculating PAS Expected Angular Start Position (A°):



$$A^{o} = \tan^{-1}\left(\frac{L}{BVD + NPD}\right)$$

BVD= *back vertex distance*

NPD= *distance from anterior corneal surface to Nodal Point, assume 6mm*

L = *distance of prism apex to visual axis*

- **PAS Lateral Extent:**
  Difference between measured and calculated:
  Normals: 3° (SD±2°)
  Hems: 3° (SD±3°)
- **PAS Position:**
  Difference between measured and calculated:
  Normals: 5° (SD±5°)
  Hems: 5° (SD±5°)
- Difference between measured and calculated greater for PAS position than for Lateral Extent
  - Includes systematic VF plotting errors
  - Includes patient's phoria @ 1 m
  - Includes errors in BVD measurement

Conclusion

- Though higher prism powers give greater VF expansion, the accompanying PAS is larger and could impact central areas of the VF in binocular viewing.
- This effect will be more dramatic for bilateral prism designs, and may affect centrally positioned prism designs (such as the Gottlieb design).
- Calculations of PAS position can provide a guide to the expected position, and could be verified with VF plots.

References:

1. Bowers A.R, Keeney K, Peli E. (2008) Community-based trial of peripheral prism visual field expansion device for hemianopia. Arch Opthalmol 126(5): 657-664.
2. Dickinson, C. Low Vision Principles and Practice. Oxford: Butterworth Heinemann, 1998, pp190-195.
3. Giorgi RG, Woods R, Peli E. (2009) Clinical and laboratory evaluation of peripheral prism glasses for hemianopia. Optometry and Vision Science *In Press*
4. *Gottlieb DD, Freeman P, (1992)* Clinical research and statistical analysis of a visual field awareness system. *J Am Optom Assoc 63(8): 581-588.*
5. Peli E. (2000) Field expansion for homonymous hemianopia by optically induced peripheral exotropia. Optometry and Vision Science 77: 453-464

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Commercial Relationships: Patent Eli Peli