

Distortions to visual field expansion with high-power Fresnel prisms

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Directing prism serration outward rather than eyeward results in wide field expansion and fewer spurious reflections for patients.

Prisms are used to expand the visual field of patients with peripheral visual field loss. For instance, patients with homonymous hemianopia (HH) have lost half their visual field on the same side in both eyes: see Figure 1(a). They can compensate for field loss by using spectacle-mounted prisms.¹⁻³ Fitting prisms on only one carrier lens achieves actual field expansion by providing different views to each eye: see Figure 1(b). When conventional ophthalmic prisms are used for vision correction, their weight and size limit the prism power to about 20 prism diopters (Δ) and hence also the amount by which the visual field can be expanded. (A prism of power 1Δ would displace an image by one centimeter at one meter.)

An approach to fitting high-power prisms for HH was proposed by Eli Peli: see Figure 1(b).⁴ The 'Peli lens' is now marketed by Chadwick Optical (Souderton, PA).⁵ High-power Fresnel prism segments are placed across the upper and lower peripheral portion of the lens. Fresnel prisms are split into small segments and are small and lightweight in comparison to conventional prisms, permitting the use of up to 57Δ ($\approx 30^\circ$). Placing the prisms peripherally avoids central double vision (binocular confusion),^{1,4} which was common with previous designs,¹ while providing awareness in the periphery of objects in the blind side without scanning.

Eli Peli and I have considered the impact of the direction of Fresnel prism serration (the series of slanted surfaces of Fresnel prisms) and side effects such as spurious reflections and distortions on the patient's perception.⁶ Although the existence of prism distortions is well known, their effect on patients has not previously been considered.

Prism power varies with angle of incidence, but the power variations within the range of practical gaze shift ($\pm 15^\circ$) are very

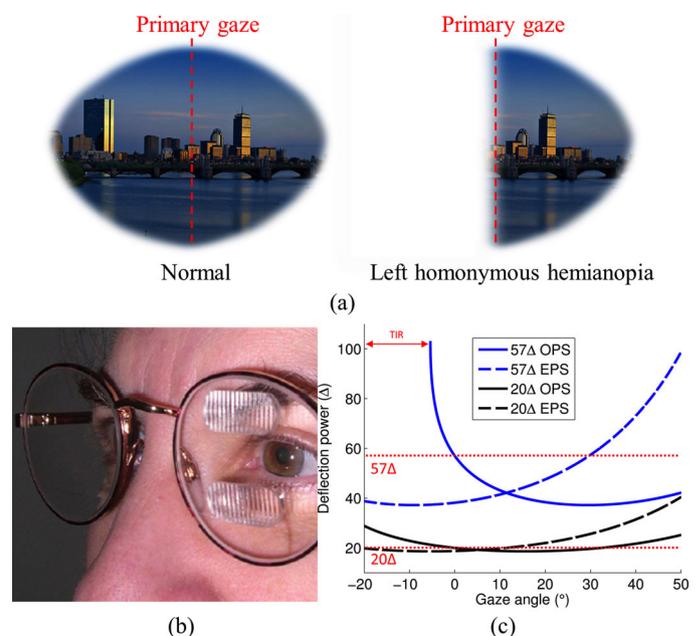


Figure 1. (a) Illustration of normal binocular visual field, compared with that of a patient with left homonymous hemianopia. (b) Peli prism glasses with prism base to the left (outward prism serration, OPS). (c) Prism power as a function of gaze direction for eyeward prism serration (EPS) and OPS.

small for a low-power prism (20Δ): see Figure 1(c).⁷ Thus the deflection power can be reasonably approximated as a constant deflection angle (CDA). However, the effective deflection angle of a high-power prism (57Δ) varies dramatically with the angle of incidence, and these effects must be considered when prescribing prisms for visual field expansion. With high-power prisms, total internal reflection (TIR) is encountered at small gaze shifts into the blind side (-5.3° with 57Δ), blocking any farther expansion with eye scanning. The effective prism power changes

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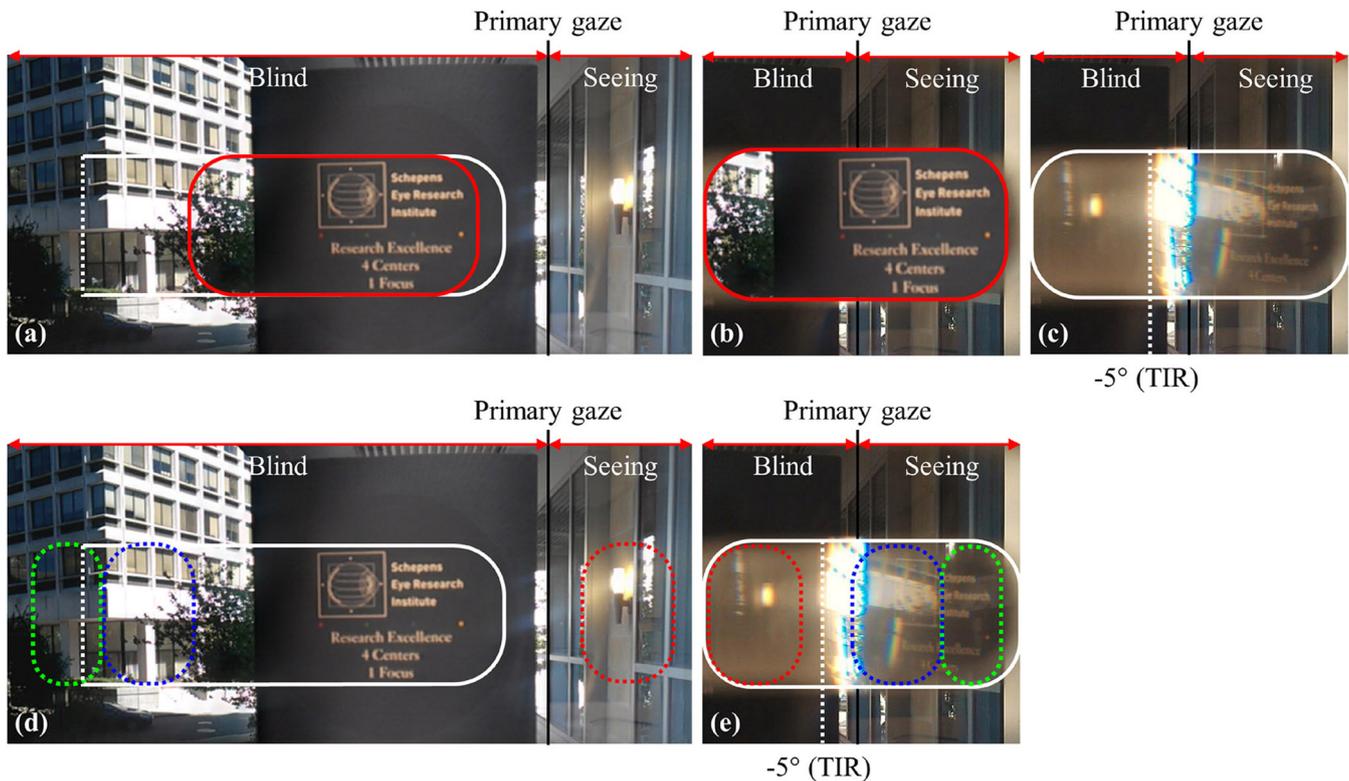


Figure 2. (a–e) Photographed and calculated views through 57Δ OPS base-left Fresnel prism (to correct left homonymous hemianopia). (a) View without prism, indicating areas that are shifted by the prism without (red solid line) and with (white solid line) distortion. (b) View calculated without taking distortion into account, under the constant deflection angle (CDA) approximation (red solid line). (c) Actual photographed view with OPS prism including distortions and reflections (white solid line). (d) View without prism. Areas affected by spurious reflections are marked. (e) Actual photographed view with OPS prism marking the locations of spurious reflections by total internal reflection (TIR) on prism base (red, strong reflection) and surface reflections (blue and green, weak reflections).

dramatically depending on whether prism serration is eyeward (EPS) or outward (OPS): see Figure 1(c).

In the OPS configuration, the view through the prism is wider and more compressed than that under the CDA: see Figure 2. TIR blocks views beyond about 5° into the blind side. In place of the desired expanded field view, that part of the prism presents spurious reflections caused by the periodic prism base structure of Fresnel prisms. While strong reflections caused by TIR on the prism base (red dashed lines) fall on the blind hemifield, weak surface reflections (blue and green dashed lines) are superimposed on the seeing hemifield. They can cause false alarms as well as reduce contrast with bright lights (such as from a headlight or sunbeam).

In the EPS configuration, the different angle of incidence reduces prism power and its variability: see Figure 3. The actual prism view is slightly magnified by the reduced prism power,

and the scanning range is not limited as TIR is not reached with normal eye movements. Although the magnified view and wide scanning range without TIR increase the visibility, spurious reflections in the EPS case are more disturbing than in the OPS configuration because both strong and weak reflections fall in the seeing hemifield.

In summary, each OPS and EPS configuration in high-power prisms has its own advantages and limitations. Although the EPS configuration has the advantages of a magnified view and wide scanning range, its spurious reflections cannot be controlled. On the other hand, the OPS configuration can be optimized for wide field expansion and reduced spurious reflection by optimizing the fitting position and size.⁶ The distribution of deflection power varies with the angle of incidence and is therefore controlled by rotating the prism. We are now working to

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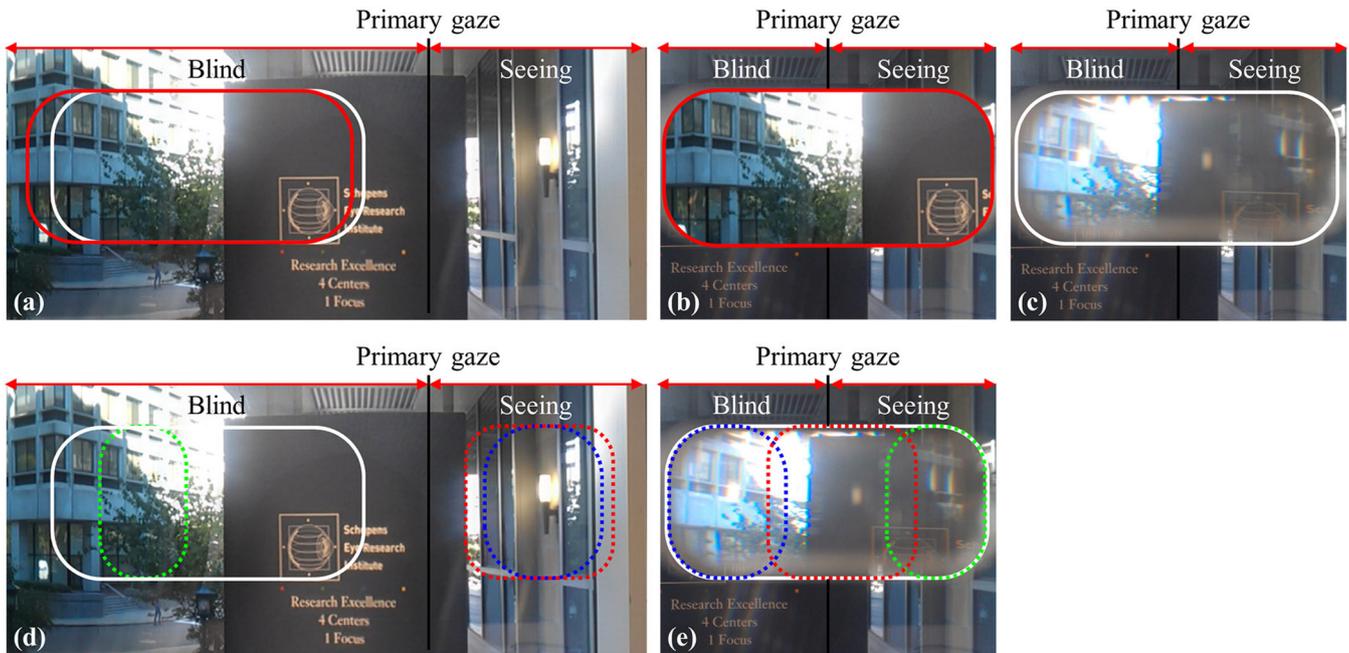


Figure 3. Photographed and calculated views through 57Δ EPS base-left Fresnel prism (to correct left homonymous hemianopia). (a) View without prism, indicating areas that are shifted by the prism without (red solid line) and with (white solid line) distortion. (b) View calculated without taking distortion into account, under the CDA approximation (red solid line). (c) Actual photographed view with EPS prism including distortions and reflections (white solid line). (d) View without prism. Areas affected by spurious reflections are marked. (e) Actual photographed view with EPS prism marking the locations of spurious reflections by TIR on prism base (red, strong reflections) and surface reflections (blue and green, weak reflections).

develop other related configurations of field-enhancing prisms (e.g., for monocular vision, bitemporal hemianopia, or the extreme temporal field of normal people).

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