Article • Importance of Longitudinal Visual Function Assessments after Orbital Cavernoma Removal

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ABSTRACT

Background: Orbital cavernomas are lesions consisting of blood-filled cavities located at the optic chiasma and retro-chiasmal afferent visual pathways. Treatment of cavernoma is often via surgical excision. Visual prognosis depends upon complete excision of the lesion and the extent of pre-operative visual impairment.

Case report: A 44-year-old Asian female patient attended the Emergency Department of a local hospital due to recurrent headaches, nausea, and rapid vision deterioration for six days. Medical examination revealed a cavernoma at the right optic nerve and optic chiasm, resulting in significant reduction in visual acuities (20/200 to 20/400) with severe visual field loss in both eyes. An immediate surgical operation of right pterional craniotomy and resection of the cavernoma was performed. However, only a small part of her visual field was restored. Four years later, she started treatment with Traditional Chinese Medicine, with the hope of gaining further improvement in her vision.

Conclusions: In this report, we highlight the importance of various tests of visual function, including visual field, visual evoked potential (VEP), contrast sensitivity, and color vision, for the patient at different intervals after surgical operation of the cavernoma. Interpretations of the clinical findings are made. The importance of parallel care from optometric and medical personnel is discussed.

Keywords: cavernous hemangioma, color vision, contrast sensitivity, mfVEP, orbital cavernoma, PVEP, visual function, visual field

Introduction

A cavernoma or cavernous hemangioma is a spongy tumor composed of a connective tissue framework enclosing dilated, cavernous vascular spaces filled with blood. These vascular malformations can be found in the central nervous system, head and neck, chest and abdomen, etc.[1,2] Orbital cavernoma is the most common benign vascular tumor, which is located at the optic chiasm and retro-chiasmal afferent visual pathways.[3] It is a slowly progressive lesion that affects mostly middle-aged (30-50 years) adults, and women are affected more than men. Multiple or bilateral orbital cavernous hemangiomas are extremely rare.[4,5] Magnetic resonance imaging (MRI) and computed tomography (CT) with or without contrast are the best means of diagnosing and analyzing a change in size of a cavernoma.[6]

In general, patients suffering from orbital cavernoma usually complain about recurrent headaches, seizures, nausea, and vision problems.[7]

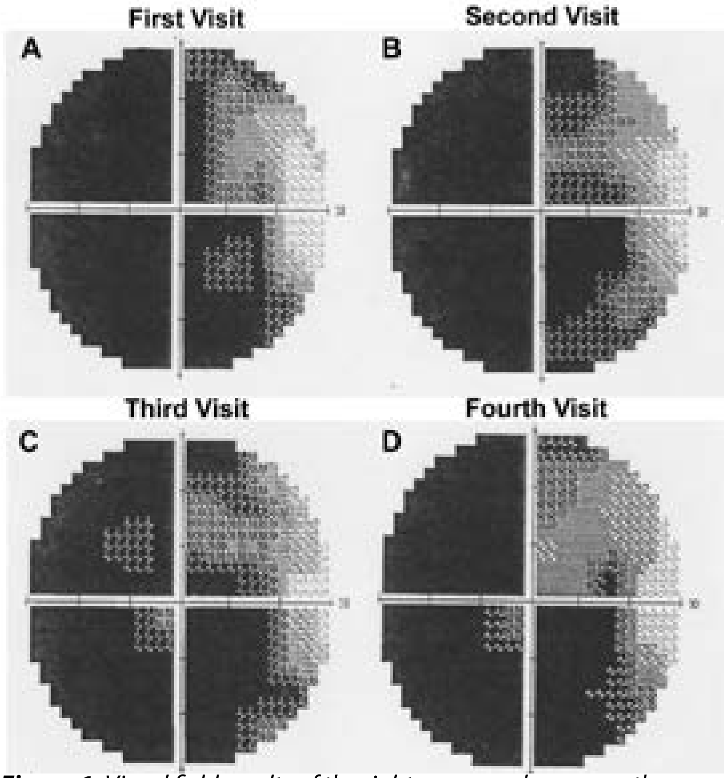

Figure 1. *Visual field results of the right eye over eleven months*

The onset of the symptoms is gradual, starting with a progressive, well-tolerated, and reducible proptosis. The nature of induced vision loss, such as visual acuity and deficits in visual fields, depends on the localization of the tumor and the extent of the compression by the tumor. For a tumor located at the optic chiasm, significant deterioration in visual acuity and bitemporal visual field loss (hemianopia) respecting the vertical meridian are expected. However, if the tumor is located at the junction of the optic nerve and optic chiasm, a junctional field defect with a complete monocular hemianopia together with an incomplete contralateral hemianopia is expected.[8] For a patient with retro-chiasmal cavernoma, a relative afferent pupillary defect and homonymous hemianopia can occur.[1] Visual acuity resulting from retro-chiasmal cavernoma is usually unaffected unless the tumor is large enough to compress the chiasm and optic nerve.

Treatment of cavernoma depends on its location, size, and symptomology.[7,9] Surgical removal of the tumor by craniotomy is an effective way to remove the seizure focus and eliminate the risk of hemorrhages, in particular when symptoms are presented. After surgery, most of the presented symptoms such as seizure can be relieved.[10] The prognosis of post-operative visual function varies according to the onset of the cavernoma, surgical approach, and extent of pre-operative visual impairment. Schick et al.[7] reported that 74% of patients with incomplete vision loss could regain their visual acuity and ocular motility after the operation. However, visual function for patients with complete vision loss could not be recovered after the surgery. In fact, in addition to visual acuity, other clinical tests such as contrast sensitivity, visual field, color vision, and electrophysiology measurements are important to reflect the subjective and objective assessments of patients' visual functions. This report illustrates the importance of longitudinal post-operative visual field and multifocal visual evoked potential (mfVEP) assessments on a patient who underwent surgical removal of a cavernoma. Correlations among different clinical findings and the importance of parallel management from optometric and medical personnel are discussed.

Case Report

Patient SYW, a 44-year-old Asian female, attended the Optometry Clinic of The Hong Kong Polytechnic University for a comprehensive vision assessment. She had been receiving Traditional Chinese Medicine (TCM) treatment, which involved the use of a combination of various traditional herbal medicines, for her eyes for 12 months with the hope of gaining further improvement in her vision after orbital cavernoma removal. The purpose of her visit was to monitor any change in her vision or visual function after one year of TCM treatment.

History

Patient SYW underwent LASIK for her myopia 7 years ago. Her correction was OD -9.50 D and OS -9.75 D before surgery. The refractive surgery was uneventful, so no spectacle correction was required after the surgery. Five years ago, she attended the Emergency Department of a local hospital due to symptoms of recurrent headaches, nausea, and rapid vision deterioration over six days. During the medical examination, a cavernoma was found at the right optic nerve and optic chiasm, resulting in significant visual acuity loss of 20/200 (6/60) to 20/400 (6/120) in her right eye, with severe visual field loss in both eyes. An immediate operation of right pterional craniotomy and resection of the cavernoma was conducted, and only a small part of her visual field was restored. No further clinical monitoring of her visual function was continued after the surgery in the hospital.

First visit

A comprehensive eye examination was performed for the patient at the Optometry Clinic of The Hong

Table 1. Summary of Patient's Clinical Findings after Cavernoma Surgery over 11 Months

<table>
<tr><th></th><th colspan="2">First Visit</th><th colspan="2">Second Visit
(4 months later)</th><th colspan="2">Third Visit
(8 months later)</th><th colspan="2">Fourth Visit
(11 months later)</th></tr>
<tr><td>Clinical tests</td><td>Right Eye</td><td>Left Eye</td><td>Right Eye</td><td>Left Eye</td><td>Right Eye</td><td>Left Eye</td><td>Right Eye</td><td>Left Eye</td></tr>
<tr><td>New manifest refraction</td><td>-2.00/-0.50x50</td><td>-1.75/-0.50x100</td><td>-2.00/-0.50x50</td><td>-1.75/-0.50x100</td><td>-2.00/-0.50x50</td><td>-1.75/-0.50x100</td><td>-2.00/-0.50x50</td><td>-1.75/-0.50x100</td></tr>
<tr><td>Best-corrected visual acuity at distance</td><td>20/250 (6/75)</td><td>$20/25^{-1}$ ($6/7.5^{-1}$)</td><td>20/250 (6/75)</td><td>20/20 (6/6)</td><td>$20/250^{+2}$ ($6/75^{+2}$)</td><td>20/20 (6/6)</td><td>$20/250^{+2}$ ($6/75^{+2}$)</td><td>20/20 (6/6)</td></tr>
<tr><td>Near acuity at 40 cm (Snellen equivalent)</td><td>4.0M (20/200)</td><td>0.5M (20/25)</td><td>5.0M (20/250)</td><td>0.4M (20/20)</td><td>3.2M (20/160)</td><td>0.4M (20/20)</td><td>3.2M (20/160)</td><td>0.4M (20/20)</td></tr>
<tr><td>Contrast sensitivity (log)</td><td>0.00</td><td>1.40</td><td>0.20</td><td>1.60</td><td>0.20</td><td>1.60</td><td>0.20</td><td>1.60</td></tr>
<tr><td rowspan="2">Visual field (central 30-2)</td><td>Complete left field loss</td><td>Peripheral left field loss</td><td>Complete left field loss</td><td>Same as first visit</td><td>Left field loss with sparing near macula</td><td>Same as first visit</td><td>Left field loss with macular sparing at inferior</td><td>Same as first visit</td></tr>
<tr><td>Right field loss (along vertical meridian)</td><td></td><td>Right field loss (lesser extent in superior region)</td><td></td><td>Right field loss (lesser extent in superior region)</td><td></td><td>Right field loss (lesser extent in superior region)</td><td></td></tr>
<tr><td>Amsler grid</td><td>Central metamorphopsia</td><td>Normal</td><td colspan="2" rowspan="5">Same as first visit</td><td colspan="2" rowspan="5">Same as first visit</td><td></td><td></td></tr>
<tr><td>Color vision</td><td>Severe color deficiency</td><td>Close to normal</td><td></td><td></td></tr>
<tr><td>Pupil reaction</td><td>Marcus-Gunn defect</td><td>Normal</td><td></td><td></td></tr>
<tr><td>Anterior eye examination</td><td>Normal</td><td>Normal</td><td></td><td></td></tr>
<tr><td>Fundus examination</td><td>Normal</td><td>Normal</td><td></td><td></td></tr>
<tr><td>Pattern visual evoked potential</td><td></td><td></td><td>No response</td><td>Reduction in amplitude</td><td>No response</td><td>Same as second visit</td><td></td><td></td></tr>
<tr><td>Multifocal visual evoked potential</td><td></td><td></td><td>No response</td><td>Reduction in amplitude</td><td>Some responses in temporal region</td><td>Same as second visit</td><td></td><td></td></tr>
</table>

Kong Polytechnic University. Visual acuities with her habitual spectacles of OD -1.00/-0.50x62 and OS -1.25/-0.50x99 were 20/630 (6/190) and $20/32^{+2}$ ($6/9.5^{+2}$), respectively. After subjective refraction, her visual acuities improved with a new manifest refraction of OD -2.00/-0.50x50 and OS -1.75/-0.50x100. Best-corrected visual acuities were OD 20/250 (6/75) at distance and 4.0M at 40 cm, and OS $20/25^{-1}$ ($6/7.5^{-1}$) at distance and 0.5M at 40 cm. Contrast sensitivity on the Pelli-Robson chart at 1 m was OD 0.00 and OS 1.40 in log units. Amsler grid testing revealed a large area of central metamorphopsia for the right eye, but it was normal for the left eye. Results of color vision testing with saturated and desaturated D15 showed a severe color vision deficiency with substantial arrangement errors, but no definite pattern for the right eye was detected. However, color vision tests for the left eye showed only minor errors in the desaturated D15 test. Table 1 summarizes the results of various clinical measurements at the baseline and subsequent visits.

The patient's pupils were equally round and reactive to light, but a positive Marcus-Gunn defect was noticed in the right eye. Anterior segment evaluation by slit lamp examination revealed no

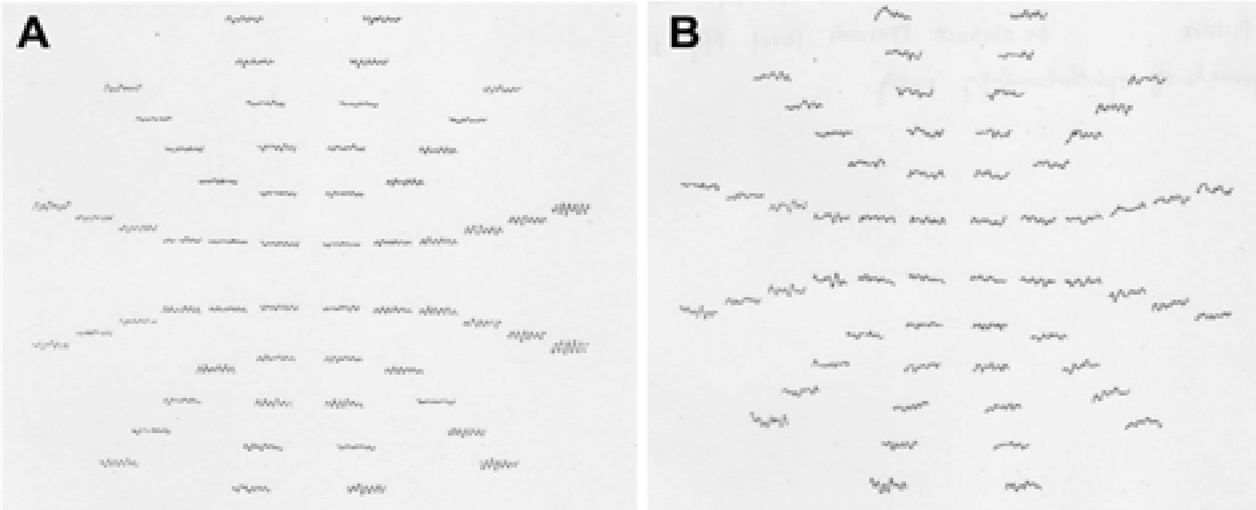

Figure 2. *Results of the multifocal visual evoked potential (VEP) of the right eye. (A) Multifocal VEP at the second visit. (B) Multifocal VEP at the third visit.*

remarkable abnormalities for both eyes. Internal ocular health assessment by fundus photography revealed optic atrophy with temporal myopic crescents in both eyes. Peripheral retina was flat and intact. No pathology was detected in either eye. Automated visual field test by Humphrey Visual Field Analyzer with the central 30-2 SITA standard protocol showed a complete nasal hemianopia with a substantial inferior temporal field loss in the right eye (Figure 1A). The left eye showed an incomplete temporal hemianopia with macular sparing, which is not shown in this report. A spectacle update was recommended at this visit.

Second visit

Four months later, the patient returned to review her refraction and other clinical visual performance. Her visual acuity remained fairly stable, with best-corrected visual acuities of OD 20/250 (6/75) at distance and 5.0M at 40 cm, and OS 20/20 (6/6) at distance and 0.4M at 40 cm. Except contrast sensitivity, the results of other clinical findings remained unchanged. Monocular contrast sensitivity improved by 0.20 log unit to OD 0.20 and OS 1.60 at this visit.

Visual electro-psychophysical tests by pattern visual evoked potential (PVEP) and multifocal visual evoked potential (mfVEP) were performed during this visit. Both PVEP and mfVEP signals were not recordable in the right eye (Figure 2A). This implies that there was a severe damage of the visual route from the right eye to visual cortex with no visual signal transmission. For the left eye, results of PVEP and mfVEP revealed a reduction in response amplitudes, in particular in the temporal field. But the latency was within the normal range (data not shown). The reduction in response amplitudes suggests that the damage in the visual pathway only involved the ganglion nerve fibers in the optic chiasm.

Third visit

Interestingly, further clinical review after 4 months showed a mild improvement in the visual function of the patient's right eye. Her best-corrected visual acuities improved slightly from 20/250 to $20/250^{+2}$ ($6/75$ to $6/75^{+2}$) at distance and 5.0M to 3.2M at 40 cm. Automated visual field test results appeared to show recovery in the upper quadrant of the temporal field along the vertical midline and in the lower quadrant of the nasal field close to the macular region (Figure 1C). The location of visual field improvement was in line with the improvement in the mfVEP responses (Figure 2B). The responses from the right eye were recordable with slight improvement in the region with better visual field (superior temporal quadrant). These regional improvements were confirmed by repeated measurements during this visit.

Fourth visit

The patient returned to our clinic 3 months later. In this visit, assessment of fixation stability and microperimetry by a Scanning Laser Ophthalmoscope (SLO) on the right eye was performed, in addition to other routine clinical measurements. Results from the SLO assessment showed a stable central fixation above the fovea with no difficulties in maintaining accurate fixation while making pursuit eye movements. In the SLO scotometry, the location and size of the scotoma were similar to that reported in the previous visual fields. Repeated visual field measurements revealed a similar recovery in the upper quadrant of the temporal field and the lower quadrant in the nasal field, which were both close to the macula (Figure 1D). The stable fixation indicated in the SLO perimetry was in line with the findings from the visual field analyzer, in which minimal fixation losses were found. These results suggested that the improvement in the visual field of the right eye was not due to eye movements or a static eye position artifact but was an actual recovery of the visual function.

Discussion

In summary, measurements of a number of visual functions were carried out over a period of eleven months for a patient who had undergone surgical excision of an orbital cavernoma. Even 5 years after surgical operation, the clinical measurements revealed a mild and gradual improvement in the vision for her right eye. However, her left eye showed steady visual performances between different visits without any obvious improvement. Reasons for the monocular improvement were probably due to continued recovery of her visual functions after the surgical treatment of cavernoma and/or the effect of TCM treatment. It was difficult to tease out the effect of natural recovery post-surgery or the TCM treatment received by the patient.

Recurrent headaches, nausea, and noticeable vision deterioration are the most-presented symptoms that are associated with brain tumor. Immediate consultation by or referral to neurology for further assessment by CT or MRI is essential to prevent possible deterioration of the disease and irreversible visual impairment. Prior to any treatment of the brain tumor, measurement of a number of visual functions, such as visual acuity, contrast sensitivity, visual fields, electrophysiological tests, and color vision, is important to generate baseline data so that progress in the recovery of visual function can be evaluated across time. Once the diagnosis of cavernoma is confirmed by a medical practitioner, surgical treatment is often implemented. The optometrist's role is to monitor pre- and post-surgical vision-related functions to monitor the progress in vision recovery. As in the case discussed here, this patient should have regular review of her visual functions every 6 months after her surgical removal of cavernoma.

Contrast sensitivity is a measure of the ability to detect objects of different spatial frequencies and at different contrasts. It provides information on the suprathreshold spatial visual function and plays an important role in reading performance in addition to visual acuity. Previous research studies have shown that deficits in contrast sensitivity result in reduced reading rate.[11-13] Owing to the correlation between reading performance and contrast sensitivity, the importance of contrast sensitivity measurement should not be underestimated in patients with cavernoma.

Visual field is a pertinent part of ophthalmic and neurological examinations. A defect in the retina or a lesion in the visual pathways is indicated if the visual field reveals an abnormal result. Specific patterns of visual field defect correlate with lesions found at particular anatomical locations at various parts of the visual pathways. Therefore, practitioners may pinpoint the location and the extent of the lesion by analyzing the patterns of the visual field defect.[8] The typical presentation of damage to the optic chiasm is a bitemporal defect, but a variety of visual field defects may suggest chiasmal involvement. At the anterior angle of the chiasm, small lesions nasal to an optic nerve at the junction of the nerve and chiasm may produce an ipsilateral monocular temporal scotoma respecting the vertical midline, which is commonly referred to as junctional scotoma. Lesions located near to the body of the chiasm and the optic nerve induce lateral chiasmal compression. This causes ipsilateral nasal hemianopia from compression of uncrossed nerve fibers originating in the temporal retina and passing through the chiasm laterally. Relative sparing of the upper temporal quadrant is caused by sparing of the fibers from the inferior nasal retina that have crossed to the other side anteriorly at the optic nerve junction and chiasm. In this case report, the automated visual field test was essential to monitor the change in the field defect longitudinally in conjunction with other clinical assessments.

Fundus assessment by an SLO can provide a live image of the fundus. In conjunction with a program for projecting symbols or letters onto the fundus, the retinal locus used to fixate the targets and the fixation stability can be fully investigated. SLO microperimetry can detect more subtle functional damage than standard automated perimetry and thus provides additional information about the visual field defects.[14,15] Nevertheless, clinically, perimetry conducted by SLO is very cost-ineffecive and time-consuming since additional software programs for perimetry, experimental setups, and image analysis are required. In this case, instead of conducting a central visual field perimetry by the SLO, regional perimetry at the location close to the macula and areas with improvements in visual field by a Humphrey

Visual Field Analyzer were sufficient to provide more meaningful results.

The patient in this case showed an improvement in the visual field of her right eye in her latest ophthalmic review. However, this measurement is subjected to variation in the patient's response or compensatory eye movement. It is debatable whether the improvement in the visual field is not an artifact but a true improvement in her visual function unless a number of repeated measurements have been taken or an additional objective measurement on the stability of the fixation is included to confirm that the result is reliable.[8] For this reason, to confirm that this was not the case, we conducted the SLO fixation stability and microperimetry, mainly to validate any change or recovery of the visual function which was shown by the standard automated perimetry.[16]

In addition to the subjective measurements, objective assessment of the patient's electrophysiological responses is necessary to provide information in relation to the function of the visual pathways. These measurements do not rely on the patient's subjective response and are important to the diagnosis and management of diseases along the visual pathway.[17] There are a number of electrophysiological tests available for different diagnostic and functional assessments. In this case, VEP is useful in examining the cortical function of the intracranial visual pathways, particularly the optic nerve and optic chiasm. Abnormal response patterns and altered amplitudes/latencies of the VEP measurements result from lesions in the visual pathway.

Conclusions

Orbital cavernoma is histopathologically benign. Surgical intervention is often required to prevent further deterioration and irreversible visual impairment. Various visual function tests, including visual acuity, visual field, VEP, contrast sensitivity, and color vision, prior to and longitudinally after surgery, are essential to evaluate the progress in the recovery of visual function. Therefore, regular follow-up by optometrists is essential for patients with this relatively common primary benign orbital tumor.

References

1. Liu GT, Volpe NJ, Galetta SL. Neuro-ophthalmology Diagnosis and Management. 2nd ed. Philadelphia: Saunders, 2010.
2. Gaillard F. Cavernous venous malformation. Available from https://radiopaedia.org/articles/cavernous-venous-malformation-1. Last Accessed May 6, 2021.
3. Calandriello L, Grimaldi G, Petrone G, Rigante M, et al. Cavernous venous malformation (cavernous hemangioma) of the orbit: Current concepts and a review of the literature. Surv Ophthalmol 2017;62(4):393-403.
4. Deng C, Hu W. Multiple cavernous hemangiomas in the orbit: A case report and review of the literature. Medicine 2020;99(29):e20670.
5. Hentati A, Matar N, Dridi H, Bouali S, et al. Bilateral orbital cavernous hemangioma. Asian J Neurosurg 2018;13(4):1222-4.
6. Young SM, Kim YD, Lee JH, Woo KI. Radiological analysis of orbital cavernous hemangiomas: A review and comparison between computed tomography and magnetic resonance imaging. J Craniofacial Surg 2018;29(3):712-6.
7. Schick U, Dott U, Hassler W. Surgical treatment of orbital cavernomas. Surg Neurol 2003;60(3):234-44.
8. Wirtschafter JD. Anatomic basis and differential diagnosis of field defects. In: Walsh TJ, ed. Visual Fields: Examination and Interpretation. San Francisco: American Academy of Ophthalmology, 1996:39-84.
9. Boari N, Gagliardi F, Castellazzi P, Mortini P. Surgical treatment of orbital cavernomas: Clinical and functional outcome in a series of 20 patients. Acta Neurochir (Wien) 2011;153(3):491-8.
10. Herman P, Lot G, Silhouette B, Marianowski R, et al. Transnasal endoscopic removal of an orbital cavernoma. Ann Otol Rhinol Laryngol 1999;108(2):147-50.
11. Brown B. Reading performance in low vision patients: Relation to contrast and contrast sensitivity. Am J Optom Physiol Opt 1981;58(3):218-26.
12. Rubin GS, Legge GE. Psychophysics of reading. VI--The role of contrast in low vision. Vis Res 1989;29(1):79-91.
13. Leat SJ, Woodhouse JM. Reading performance with low vision aids: Relationship with contrast sensitivity. Ophthal Physiol Opt 1993;13(1):9-16.
14. Lima VC, Prata TS, De Moraes CG, Kim J, et al. A comparison between microperimetry and standard achromatic perimetry of the central visual field in eyes with glaucomatous paracentral visual-field defects. Br J Ophthalmol 2010;94(1):64-7.
15. Markowitz SN, Reyes SV. Microperimetry and clinical practice: An evidence-based review. Can J Ophthalmol 2013;48(5):350-7.
16. Jamara RJ, Van De Velde F, Peli E. Scanning eye movements in homonymous hemianopia documented by scanning laser ophthalmoscope retinal perimetry. Optom Vis Sci 2003;80(7):495-504.
17. Corbett MC, Shilling JS, Holder GE. The assessment of clinical investigations: The Greenwich Grading System and its application to electrodiagnostic testing in ophthalmology. Eye (London, England) 1995;9(Pt 6 Su):59-64.

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Yu WY, Cheong AMY, Chan HHL, Lee MH KG, Woo GC. Importance of longitudinal visual function assessments after orbital cavernoma removal. Optom Vis Perf 2021;9(2):80-5.

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Article • Increasing Peripheral Visual Field Awareness Using Sectoral Fresnel Prisms: Review of a Model for Step-Wise Evaluation and Fitting

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ABSTRACT

Background: Severe peripheral visual field (PVF) loss can negatively impact a person's functional performance with activities of daily living, particularly mobility. The inability to navigate safely and efficiently has been associated with an increased risk of falls and injuries, as well as feelings of depression and isolation. Although no curative treatment is available for PVF loss, compensation is possible with visual field enhancement therapy (VFET). VFET using sectoral Fresnel prisms is a concept that has been documented as a viable treatment option for improving PVF awareness. Sectoral Fresnel prisms displace images from the patient's non-seeing field into their seeing field, making potential hazards more visually accessible. As a result, sectoral Fresnel prisms have the potential to improve motor performance and to enhance the overall quality of life in those suffering from visual field loss.

Case Reports: Two cases are discussed demonstrating the West Haven Veterans' Administration protocol and techniques used when fitting sectoral Fresnel prisms in both conventional and non-conventional clinical cases. The first case is a conventional sectoral Fresnel prism fit on a patient with a left homonymous hemianopsia. The second case demonstrates a challenging fit on a monocular patient with end-stage glaucoma having an overall severely constricted field. Both patients were successfully fit with sectoral Fresnel prisms, and after training, they were able to achieve their primary goal of safe and independent travel.

Conclusion: Sectoral Fresnel prisms have historically been a clinically accepted tool for rehabilitating patients with PVF loss. Recognizing functional difficulties secondary to PVF loss and identifying appropriate candidates for sectoral Fresnel prism therapy is critical to helping these patients. However, conflicting opinions regarding patient-selection criteria, prism power, and prism placement have resulted in a lack of clinical guidance or a standardized protocol for evaluating and treating these cases. Successful outcomes with sectoral Fresnel prisms are dependent upon patient selection, patient education, demonstration, fitting technique, and training. This paper serves as an overall guide by discussing a model successfully used in the WHVA for evaluating and prescribing sectoral Fresnel prisms. Emphasis is placed on the importance of interdisciplinary training to ensure safe use and long-term prism acceptance.

Keywords: constricted visual field loss, homonymous visual field loss, peripheral visual field awareness, sectoral Fresnel prisms

Introduction

Peripheral visual field (PVF) loss can result from several ocular pathologies, including glaucoma, retinitis pigmentosa, choroideremia, gyrate atrophy, and diabetic retinopathy. It can also be the result of stroke, brain trauma, brain tumor resection, or other cortical pathology. Visual field (VF) loss from ocular pathologies such as glaucoma and retinitis pigmentosa tends to progress gradually over time, and in advanced disease can result in severe overall 360-degree VF loss. In contrast, VF loss resulting from cortical pathology such as a cerebrovascular accident (CVA) is typically more sudden and acute and usually involves a sector of the VF. Homonymous hemianopsia (HH) is the most common type of VF defect in patients with acute CVA.[1] About two-thirds of VF loss associated with CVA is HH, and only 10% have a spontaneous full recovery within the first two weeks.[1] Other types of VF field loss that may occur after a CVA are quadrantanopia, overall constriction, altitudinal defects, and scotomas. Regardless of etiology, or whether VF loss is gradual or acute, advanced overall constricted and HH VF loss compromises one's ability to interact safely and efficiently within their environment. Consequently, PVF loss may significantly affect the day-to-day functioning of these patients, decreasing their quality of life.

Peripheral vision is responsible for detecting movement and gathering information about one's surroundings. The peripheral visual system uses information received from rod photoreceptor cells, making it very sensitive to detecting light and motion.[2] These cells function best in low and dark illumination and provide night-time vision.[2] Damage to the peripheral visual system, including rod photoreceptors, from ocular or cortical pathology will often cause characteristic visual impairment symptoms. Overall, patients with advanced PVF loss will demonstrate navigation difficulties in both photopic and mesopic environments.[3] Some will struggle when performing search and location tasks, as this skill is also dependent upon receiving information from the peripheral visual system.[4] Simple tasks such as cooking, cleaning, laundry, self-grooming, driving, and paying bills can become quite challenging for these patients. Additionally, reading ability may become compromised when PVF loss encroaches on central vision.

Of significance is the detrimental impact that severe PVF loss has on orientation and mobility.[5,6] The loss of safe and independent travel can lead to substantial visual disability and visual handicap. These patients tend to walk with hesitation, shuffle their feet, veer to one side, and miss objects in their non-seeing field, increasing the risk for falls and injuries.[7] When the VF loss becomes severe, some may choose to remain indoors, restrict activities, and even become immobilized as a result of not feeling secure when ambulating.[7] Such avoidance behaviors can negatively impact social interactions and limit activities, resulting in feelings of isolation and depression.[7] In certain cases, the psychosocial ramifications of the impairment can be more debilitating than the actual loss of vision.[8]

Confident and efficient navigation relies heavily on the PVF system. Haymes et al.[9] reported on patients with retinitis pigmentosa and stated that mobility performance declined when there was constriction of the VF within the central 20-degree diameter. Additionally, Hassan et al.[10] elaborated on these findings and reported that image contrast is another important factor to consider when determining the critical field of view (FOV) size for effective mobility and navigation. They found that a larger FOV is required under low-contrast conditions, and a smaller FOV can be used for high-contrast conditions.[10] While mobility relies heavily on the visual system, physical and cognitive deficits can also contribute to difficulties and should be factored in when evaluating VF impairment.[11]

Over time, many patients learn to adjust for their VF loss on their own by developing compensatory strategies, which are often inefficient and not systematic. In patients with overall constricted PVF loss, some develop a behavior referred to as shoe gazing.[8] These patients tend to perseverate and spend all their visual energy looking down to help detect objects or drop-offs. Such behavior prevents them from using their eyes to scan more globally and systematically in order to ensure proficient and safe navigation. Other patients adapt with erratic scanning patterns or by using excessive head-neck movements.[8] Similarly to patients with overall constricted VF loss, patients with HH may compensate on their own with inefficient strategies. Some may habituate with a slight head turn that is usually directed toward the side of the VF defect and/or develop unorganized eye movements while scanning into their non-seeing field.[8] Although many patients with HH and overall constricted VF loss develop inefficient compensatory scanning strategies on their own, some do develop proficient head- and eye-scanning techniques.[8] Scanning with efficient systematic search patterns provides the patient with a more complete picture of their surroundings and allows for detection of potential hazards.[11] However, even if patients start to acquire these strategies independently, structured mobility training should be initiated to ensure that the appropriate skills have been developed for safe travel in both HH and constricted VF loss.[12] Orientation and mobility (O&M) training will focus on improving exploratory behavior skills by integrating scanning techniques, auditory cues, and the use of a long cane for tactual clues.[12] O&M professionals are available both within the VA and in private-sector workforces such as State Services for the Blind, making them available for hire on a case-by-case basis. In Veterans' Administration Medical Centers (VAMC), patients are provided with O&M professionals. In the private sector, legally blind patients will receive O&M training at no cost through State Services, whereas non-legally blind patients will incur a cost for this therapy. However, when considering the various degrees of physical, social, and psychological risks, the cost of intervention is more than justified. Referring to an O&M specialist gives the optometrist peace of mind, provides the highest standard of care, promotes the successful use of prism, and is medicolegally prudent. With this specialized training, patients are given an opportunity to compensate for their VF loss, improve visual function with activities of daily living (ADLs), and regain their independence, making it well worth the investment.

In addition to receiving training with O&M professionals, there are several other low vision (LV) treatment options available to help enhance PVF awareness. Optical devices such as reverse telescopes, minus lenses, amorphic lenses, mirror systems, and prisms have been documented as effective mobility aids for patients with advanced VF loss. Reverse telescopes, amorphic lenses, and minus lenses can be used in patients with overall constricted VF loss.[6,11] These systems minify images, thereby compressing more of the visual cues and environment into the patient's remaining field.[11] However, this minification effect proportionally decreases visual acuity (VA) and clarity.[6] Such systems are better suited for spotting and providing information regarding the layout of an unfamiliar environment.[11] Historically, mirror systems were a treatment option for patients with HH VF loss. Objects from the missing field seen through the mirror are reversed and superimposed onto the patient's seeing field.[13] The patient simultaneously perceives information from both the seeing and non-seeing fields and is made aware of potential hazards from the missing field.[11] However, patients often find it difficult to process two images simultaneously: a reversed image from the mirror that overlays a normal image from their seeing field.[13] This may cause the patient to become spatially disoriented.[14] Additionally, patients also find it difficult to deal with image motion caused by head movement.[11] Due to these adverse effects, as well as poor cosmesis, mirror systems are hardly ever prescribed for treating HH VF loss.[11,13,14]

With the adverse effects of mirror and minifying systems, over time, prisms became a more-accepted option for enhancing PVF awareness. Prisms have the optical property of shifting the image towards the apex of the lens. When oriented with the base towards the VF defect, the image is shifted towards the seeing field, allowing for much more immediate access to peripheral visual information.[14] Two different methods can be used to fit prisms: full field or sectoral. Full-field prisms are placed over the entire spectacle lens and shift the whole VF toward the seeing field. This allows for a portion of the non-seeing field to be appreciated at the expense of an equal amount of field loss from the seeing field.[13] Additionally, shifting the whole field including intact VF areas can be spatially disorienting to some users. Moreover, full-field prisms are typically only tolerated up to 15 prism diopters due to cosmesis and unfavorable optical qualities.[13] This, in turn, has made full-field prisms a less-favorable option. In their place, sectoral prisms, which are positioned over a portion of the spectacle lens, have become the preferred prism option for PVF enhancement therapy.

Pelli and Fresnel are the main sectoral prisms currently prescribed today. Pelli prisms are specialized sectoral prisms used as a peripheral visual field enhancement therapy (VFET) in patients suffering from HH or quadrantanopsia, but not in cases of overall VF loss.[13] Oblong prisms are placed superiorly and/or inferiorly over the eye that correlates to the same side as the VF loss. Prism bases are orientated toward the direction of the VF defect.[13] The specific placement of the prisms allows the user to have increased awareness from the blind field while viewing straight ahead.[14] Sectoral Fresnel prisms provide increased peripheral awareness for patients suffering from both HH or overall constricted VF loss.[13,14] They have been a long-established treatment option with proven documented success for HH and overall constricted VF loss.[5,13,14,16,17] Primarily, they serve as an aid to allow safe, independent travel and can be purchased at a low cost. Fresnel prisms are made of a lightweight, polyvinyl chloride plastic and are easy to mount and to remove.[7] These features have made them an appealing rehabilitation option for some time. Sectoral Fresnel prisms work by relocating images from the patient's missing field toward their central, seeing field.[5] They do not expand visual fields, which is an important concept to explain to patients when introducing this aid as a treatment option.[16] Sectoral Fresnel prisms widen the amount of territory that a patient with VF loss is able to survey using comfortable eye scanning movements.[14,16] Without the use of these prisms, patients typically have a limited range of easy eye scanning movements into the direction of field loss. Beyond that point, scanning for peripheral information will require more exaggerated eye, head, and neck movements into the missing field.[16] When patients scan into sectoral Fresnel prisms, they receive peripheral information from their non-seeing field sooner and with smaller eye excursions, thereby eliminating the need for excessive head and neck movements.[11,14,16] Sectoral Fresnel prisms increase the effect of a patient's habitual scanning skills, causing them to become proficient scanners.[16] This allows them to be more aware of their environment and feel more secure when traveling.

To be successful with sectoral Fresnel prisms, patients will need to complete comprehensive training. Training is a critical factor for prism acceptance and long-term success. Hoppe and Perlin[13] noted that patients who were surveyed after being dispensed sectoral Fresnel prisms reported that they were overall satisfied with the benefits and results of the prisms. However, one of the problems reported by the patients was the need for more training time. Prism education and training is first conducted by the optometrist, who then works collaboratively as needed with any of the following professionals: an occupational therapist (OT), certified LV therapist (CLVT), or vision rehabilitation therapist (VRT) to ensure that the patient understands how the prisms work, what they are designed to do, and how to use them. Most importantly, the optometrist should engage O&M specialists to verify that the appropriate O&M compensatory strategies and skills have been trained prior to prism fitting and prism use. Whether or not prisms are incorporated into low vision rehabilitation (LVR), O&M training is an intervention that is necessary and should be recommended in any case where PVF loss is impacting the patient's function and mobility skills.

This paper serves as an overall guide for evaluating and prescribing sectoral Fresnel prisms. In turn, the recommended protocol will require a minimal purchase of a tangent screen, a willingness to experience this model, and a commitment to work on proficiency in a stepwise manner. The guideline presented has been clinically trialed, proving to be an effective VFET.[11] A review of applied modifications to a method developed, trialed, adopted, and refined by the Eastern Blind Rehabilitation Center (EBRC) at the West Haven Veterans' Administration (WHVA) is discussed. Clinical guidelines for identifying, evaluating, prescribing, and executing a successful Fresnel prism fit will be reviewed. We will also highlight post-fit training, including referring/working with an O&M professional, and emphasize the importance of an interdisciplinary approach to ensure long-term success. Cases will be reviewed, serving as a practical demonstration for the clinical application of the recommended fitting protocol, in a conventional and a more challenging case.

Introduction: Fresnel Prism Evaluation

Background

In 1975, Dr. Robert R. Perlin developed a protocol for fitting Fresnel prisms at the EBRC located at the WHVA. At that time, the EBRC offered an extended inpatient program that focused on helping visually impaired veterans become more proficient with ADLs by providing extensive training in the areas of low vision, manual skills, living skills, and O&M. To improve and standardize his Fresnel prism fitting technique, Dr. Perlin conducted a clinical study.[13] The goal of this study was to determine the success rate and the factors that influenced prism acceptance. Dr. Perlin was able to develop a more objective and reproducible technique over time by extrapolating from this clinical study, his clinical experience, and patient feedback. However, over the years, the duration of the inpatient program was shortened. To accommodate this change, Dr. Perlin's Fresnel prism fitting technique was further modified and adapted under the direction of Dr. Kara Gagnon. Prism power and placement and the candidate selection criteria described below reflect the current model used at the EBRC.

The Ideal Candidate

Case history is crucial for identifying patients who would benefit from VFET.[11] Clinicians can sometimes overlook problems associated with VF loss, as many of these patients will present with good visual acuity (VA). A thorough and detailed history will elicit functional problems associated with completing ADLs, reveal any mobility concerns, and determine the need or desire to travel independently. Questions should include asking about bumping into objects, veering to one side while walking, and a history of

Table 1. Fresnel Prism Ideal Candidate Criteria

Peripheral field loss
a) Constricted: residual field 5-15 degrees b) Homonymous hemianopsia: macula sparing
Need to travel independently
Motivation
Intact cognition
Stable temperament
Proficient with white cane and mobility skills

falls or injuries.[7,11] Special attention should be placed on difficulties with search and location tasks, such as finding street signs or noticing when people are present on their right or left sides.[11] The optometrist should also carefully observe the patient's motor performance as the patient is escorted to the examining chair. The clinician should be cognizant of habituated head turns or postural shifts, as well as the use of compensatory scanning patterns. Is the patient overly cautious and extremely hesitant? Do they shuffle their feet, walk into objects, or drift to one side?[7] Such observations provide valuable information regarding how the VF loss is interfering with the patient's ability to navigate and to interact with their environment.

Choosing an appropriate candidate is critical for ensuring immediate and continued success with Fresnel prisms. Based on Dr. Perlin's initial clinical protocol, there are several criteria that need to be satisfied in order to be considered a good candidate for Fresnel prisms (Table 1). The size and shape of the residual central VF in those with overall VF constriction or HH VF loss plays an important role in patient selection. Perlin and Dziadul[14] noted that for patients with an overall constricted VF loss, prism acceptance and success is more likely if the residual VF is between 5-15 degrees in diameter, with no peripheral islands of vision remaining.[5,13] Typically, patients who have a VF of 20 degrees or greater will have minimal, if any, difficulty navigating their environment and may not benefit from Fresnel prism therapy.[9] Moreover, patients with less than 5 degrees of remaining field usually have a difficult time adapting to Fresnel prisms.[14] Many of these patients have already habituated with extreme head and postural positions that provide them with a sense of security.[5,14] They may feel anxious about adopting an aid that will interfere with strategies that they have become accustomed to using during ambulation. However, this 5- to 15-degree range of remaining VF recommended by Perlin and others[5,13,14] is simply a guideline for those patients who have proven to have the most functional benefit from sectoral Fresnel prisms, but this should not be rigidly observed. The actual size of a VF can be misleading due to various visual and non-visual parameters, such as acuity level, contrast sensitivity, glare sensitivity, age, physical or motor difficulties, cognitive level, and lifestyle demands, all of which can influence mobility performance and impact prism acceptance and success.[8] Therefore, symptomatic or functionally challenged patients should not be excluded from consideration of treatment even if they fall outside the suggested VF criteria. When considering sectoral Fresnel prisms for patients with HH VF loss, it is ideal for macula sparing to be present.[14] Additionally, patients with central scotomas and relatively normal VFs would not be candidates for Fresnel prism VFET.[14]

Remaining peripheral islands of intact vision can influence the acceptance of sectoral Fresnel prisms. Patients who have these residual islands may already be using them efficiently to navigate and to detect peripheral information. Often, it is more ideal to make these patients aware of these peripheral islands and teach them how to use them instead of introducing sectoral Fresnel prisms.[13,14] Success with sectoral Fresnel prisms in such cases will ultimately depend on the size of these existing peripheral islands and the patient's ability to deal with displaced images within these residual fields.[5]

In patients with both VF and VA loss, the plastic material of Fresnel prisms will further degrade vision and can negatively influence prism acceptance. The literature has varying opinions regarding the optimal acuity for prescribing sectoral Fresnel prisms. Some argue that reduced acuities of 20/200 or less present a great challenge for fitting sectoral Fresnel prisms since vision will be too blurred through the prisms.[13,18] However, others argue that acuities do not predict whether a patient will accept Fresnel prisms. They found that many of their greatly reduced acuity cases were successfully fit with sectoral Fresnel prisms, while many of their patients with 20/20 vision did not accept prisms.[14,17] Likewise, Hoppe and Perlin[13] documented that patients with 20/200 vision were just as satisfied with sectoral Fresnel prisms as those with 20/20 vision. It would behoove the optometrist to trial sectoral Fresnel prisms in patients with reduced VA, as these patients may still benefit from this therapy.

Perlin and Dziadul[14] urge clinicians to be cautious when recommending sectoral Fresnel prisms for patients who are aphakic or highly myopic. High-powered lenses cause peripheral lens aberrations, and since sectoral Fresnel prisms are placed peripherally on the lens where the distortion is most prominent, these cases may not be ideal.[5] The use of contact lenses with a spectacle over-refraction and Fresnel prism application may provide a solution to overcome the adverse effects of these high dioptric spectacle prescriptions.[14] A head tilt is also typically a contraindication for fitting sectoral Fresnel prisms, as the eyes may not enter the prism in synchrony. This can potentially induce confusion and/or diplopia. However, a slight habituated head turn is acceptable as long as the head turn is maintained throughout the entire fitting process. Clinicians should be aware of any cognitive impairments that would inhibit the patient from learning the skills required to use the prisms properly.[14] Wearers must be able to understand the concept of sectoral Fresnel prisms and how they work. It is imperative that patients recognize the limitations and adverse effects of the prisms to ensure safe and effective use without posing a risk for harm.[12]

A patient is more likely to accept and to enjoy sectoral Fresnel prisms if they have a need or desire for independent travel.[5,14] Inactive patients, those wheelchair-bound, or those who already rely on a sighted guide may not be the most appropriate candidates.[14] It is also important to consider the temperament of the patient when determining patient candidacy. Any evidence of anxiety or psychological instability can be a contraindication.[12] The adverse effects of prisms and the optical displacement of images can initially be confusing and cause distress.[5,13,14] This may heighten or exacerbate any anxiety. Patients should be highly motivated to use sectoral Fresnel prisms.[13,14] They must be willing to learn and to put the required time into completing training, including O&M. White cane proficiency is mandatory for patients who will use the prism as a mobility aid. Sectoral Fresnel prisms are an adjunct therapy to be used in conjunction with mobility and long cane skills.[14] Patients should be adept at using the skills taught in O&M, including compensatory visual skills (scanning) and non-visual compensatory skills (auditory and proprioceptive), prior to prism use and while using Fresnel prisms to ensure safe and efficient ambulation.

Initial Low Vision Examination

The evaluation begins with a thorough LV examination. This exam should include a meticulous refraction, binocular work-up, full ocular health exam, central/peripheral VF testing, and a tint assessment.[14] A detailed refraction will ensure that the patient will be viewing through their best correction for optimal clarity. Eliciting symptoms of binocular dysfunction will help detect binocular vision anomalies, which can be inherent in this population.[19] Motor fusional eye movements are needed to maintain sensory fusion and are a function of the extrafoveal retinal periphery.[20] PVF loss can place stress on the motor fusional system, causing phorias to decompensate and/or tropias to manifest. Due to this lack of peripheral fusion, regardless of whether or not the patient is symptomatic, binocularity should be assessed. Aligning prism should be prescribed to correct a binocular instability. It is critical to include this aligning prism in the spectacle prescription prior to Fresnel fitting to ensure fusional stability.[14]

Performing central and peripheral VF testing before fitting Fresnel prisms is critically important and cannot be overlooked. The size, location, and extent of the VF loss must be quantified in order to determine the patient's likelihod of ambulating safely and to determine whether the patient is an ideal candidate for this therapy or whether the patient would benefit from another LVR treatment/training option.[9,14] The clinician will need to obtain an accurate map of the patient's field of vision to rule out any potential complications that may influence prism acceptance, such as residual peripheral islands of vision.[5,13,14] In addition, the VF mapping will give a full understanding of the patient's visual function, which is essential when fitting a VFET mobility aid. Goldmann perimetry or manual perimetry is the preferred choice, as it can assess 180 degrees of vision, providing the most information[11,19] However, the Goldmann perimeter is no longer in production. In its place, automated perimeters with combined capabilities of static and kinetic perimetry are available and may be used. Additionally, tangent screen testing in patients with advanced VF loss serves as an adjunct to static or kinetic perimetry. It provides quick and reliable information about the central 25-35 degrees of VF without fatiguing the patient.[9] The tangent screen helps determine the extent, location, and density of blind spots, as well as the presence of residual islands. Scotomas found within this central 25-35 degrees are most damaging to VA and mobility, and such information may be more useful in explaining and understanding the patient's current level of function and performance.[9]

A tint evaluation should be performed prior to fitting Fresnel prisms. In many patients with PVF loss, the underlying pathology impacts rod function.[5] These patients usually rely on cone vision and will tend to function best in bright to moderate illumination.[5] However, they are also sensitive to glare, which can be exacerbated with the use of Fresnel prisms. Each prism base reflects light, inducing glare and discomfort.[17] To combat glare concerns, blue blockers (amber, yellow, and orange) with a minimum of 80% transmission and an anti-reflective coating are often prescribed.[13]

After determining that the patient is an appropriate candidate for Fresnel prism therapy, the optometrist will introduce the concept of prism to the patient. This introduction should provide the patient with a broad overview regarding the purpose of the prism, including limitations, adverse effects, and specific training requirements to improve success. This education will confirm the patient's willingness and level of motivation to proceed with the fit. Information is also provided regarding the fabrication process of Fresnel prisms and the adverse effects that can result from this process. High dioptric prism powers are needed for a patient to appreciate a noticeable image shift. However, greater prism powers produce very thick, heavy lenses with poor cosmesis.[11] To reduce the thickness of the lenses, Fresnel prisms are fabricated as a press-on, flexible vinyl made up of multiple tiny prisms.[22] Although this plastic material is thinner, lightweight, and more cosmetically appealing, it provides poor optics.[13] Fresnel prisms decrease VA, increase glare, and decrease contrast, but typically this is not problematic as the patient will primarily be viewing through the carrier lens (non-prismatic portion), and the lenses will be tinted.[14]

Patient Indoctrination

To begin, explain to the patient that Fresnel prisms serve to increase peripheral awareness of their non-seeing field and increase scanning proficiency.[14,16] The prisms should be used as an aid for ambulation and should never be used for driving purposes. Emphasize that prisms do not expand the VF; rather, they bend light to displace images from the non-seeing field into the central, seeing field.[11,14,16] As the patient moves their eyes into the prisms, objects from their non-seeing field are suddenly brought into view. This reduces the need for large eye excursions and exaggerated head movements to see objects in their non-seeing field.[11,16] Additionally, the edge of the prism serves as a cue to draw attention to the non-seeing field, reminding them to scan into the prism to pick up peripheral information.[11]

Even though this fit should never be used for driving, describing the concept and function of sectoral Fresnel prisms by using the analogy of a vehicle's rear/side view mirror has shown to be beneficial for patient comprehension.[12,14] Similar to driving, by scanning their eyes briefly into the prisms, the patient can gather peripheral information quickly about obstacles or potential hazards in their environment, obviating the need for a head sweep. The patient is also made aware that images seen through the prism are less clear and displaced from the object's true position.[14] Compare this with a rear/side view mirror in a car. Mirrors warn drivers that "objects in the mirror are closer than they appear." The driver compensates by moving their eyes and head to view a car directly when they want to obtain its actual distance and position. Similarly, if the patient perceives a potential hazard while looking through the prism, they should turn their head toward the hazard to view through the carrier portion (i.e., the portion of the spectacles that does not contain prism). This allows the patient to locate the real object in space accurately, preventing misjudgments and accidents. For a dramatic demonstration of image displacement, place a loose 30 or 40 diopter prism in front of one of the patient's eyes and hold up a pen at eye level (Figure 1). Next, ask the patient to use their pointer finger to touch the pen tip. Take away the prism so that the patient can appreciate the real position of the actual pen in space compared to the displaced image seen through the Fresnel prisms

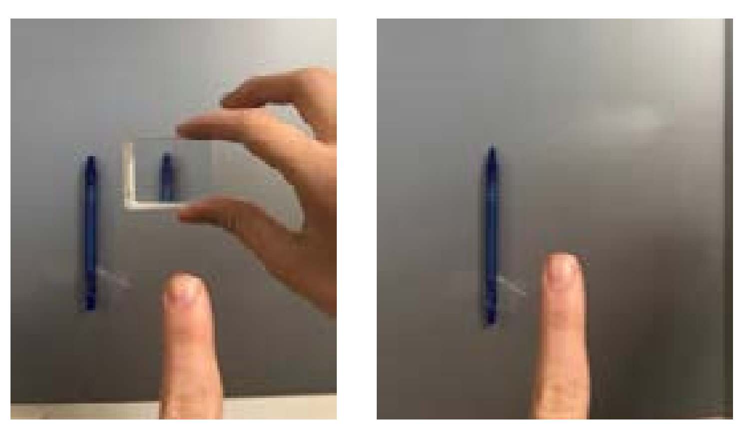


Figure 1 (left) and Figure 2 (right). *Example of image displacement as demonstrated through a loose 30 diopter prism. Note the base of the prism faces the defect, and the image of the pen is displaced toward the apex of the prism.*

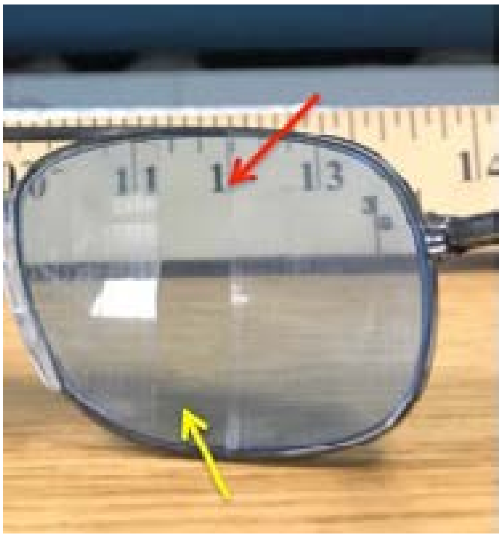


Figure 3. *The number "2" (from "12" on the meter stick) is missing due to the blind spot scotoma created at the junction of the carrier lens and prism edge. The red arrow signifies the prism edge. The yellow arrow signifies the carrier portion of the lens.*

(Figure 2). It is also important to explain that images will be displaced farther in the distance compared to at near.[21] Similarly, prism displacement increases as the prism power increases.[14]

One of the more challenging complications of sectoral Fresnel prisms is the blind spot scotoma. This scotoma is created at the junction between the carrier lens and the prism edge.[14] At this junction, a prism jump occurs, causing the image of the object to be displaced out of view (Figure 3).[11] A demonstration is provided to allow the patient to appreciate the significance of the blind spot. The clinician should hold up a pen in front of the patient's face at eye level. Have the patient view the pen through the carrier portion of the lens and follow the pen only with their eyes as you move it toward the prism edge. Ask the patient to identify the moment when the pen disappears, demonstrating the blind spot. Continue to move the pen further into the prism, until the patient can see it reappear. Explain to the patient that they can avoid this blind spot by rotating their eyes so that they are well within the prism and not at the prism edge. They may also avoid the prism edge and bypass the blind spot scotoma by turning their head to maintain a view through the carrier lens as they follow a moving target.[11,14]

It is also important to educate the patient on how to care for sectoral Fresnel prisms. Typically, it is advised that prisms are not submerged in water, as this can cause the prism to loosen and change position.[14] It is preferred that a Q-tip be dipped into a soapy cleaning solution and gently rubbed along the grain of the prism. The Q-tip can also be used to clean the carrier portion of the lens. Repeat this step, but now use a Q-tip dipped in clean water to rinse off the soapy solution.[13] Allow the spectacles to air-dry, or gently blot them with clean, dry cloth.[13] Along with proper care, patients are also educated on the low cost of Fresnel prisms, making them an economical option for VFET.[22]

Finally, a thorough explanation of the future training process and requirements should be addressed. It should be stressed that sectoral Fresnel prism therapy requires commitment and motivation on the part of the patient.[13] Patients should understand that in the beginning of the training process, they might feel that the prisms disrupt their vision. It is imperative, however, that the prisms be worn constantly and not intermittently. Intermittent wearers will have a harder time adjusting and adapting to the prisms.[14] Prism placement and power can be modified as necessary. Patients should also understand that extensive training will need to be completed. They will need to undergo O&M training and be able to demonstrate proficient mobility skills while using a white cane and the Fresnel prisms, as determined by the O&M instructor, before the prisms are dispensed to the patient for full-time wear. This additional training will teach the patient how to use the prisms and be comfortable in real-world environments.

Fresnel Prism Fitting

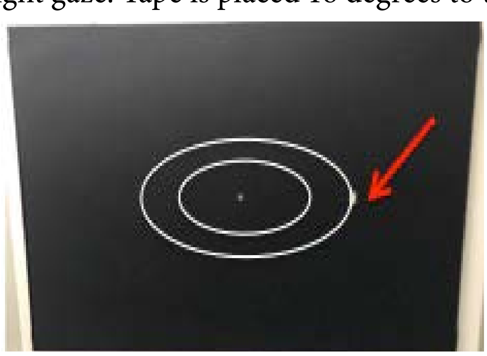
Preliminary Considerations

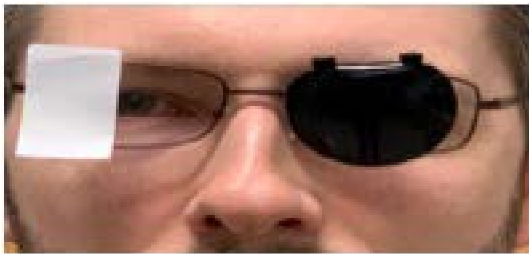
Sectoral Fresnel prisms can be fit over one or both eyes. A patient can be fit binocularly if they have single, simultaneous, binocular vision.[14] When fitting sectoral Fresnel prisms, each eye must look through the prisms simultaneously and in synchrony. In other words, when the patient looks to the left, the left eye should enter the temporal prism at the same time that the right eye enters the nasal prism. This is what is meant by synchronization, and this ensures that the patient will not have diplopia and will be able to maintain fusion. In comparison, Chea et al.[6] fit a patient with binocular vision such that only one eye would be looking through the prisms when viewing in right or left gaze. By using this method, the patient had to adapt to experiencing diplopic images. They had to learn to differentiate between the blurry virtual image seen through the prism and the clear real image seen by the non-prismatic eye.[6] Processing these 2 images simultaneously can be quite difficult and confusing for some patients. According to

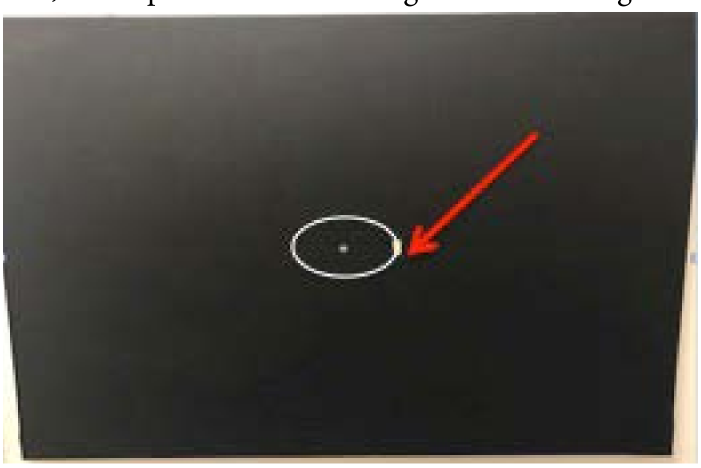
Bailey[18] and Perlin,[14] using Fresnel prisms in front of both eyes where the eyes enter the prisms at the same time is the preferred method. Fitting Fresnel prisms monocularly is more suited to cases where the patient has only one seeing eye. In these cases, the clinician has the option to fit on the temporal side only or fit nasally and temporally.[18]

When initiating a sectoral Fresnel fitting with a patient, Perlin and Dziadul[14] theorized fitting 20-diopter prism, 20 degrees from primary gaze for a patient with a 360-degree constricted VF. They based this theory on the notion that a person can make a comfortable 20-degree ocular eye rotation without having to use an accompanying head movement. Perlin[14] referred to this as the 20/20 rule. For patients with HH and macular sparing, fit a 20-diopter prism with the prism edge at 5 degrees, as these patients can tolerate and benefit from a tighter fit.[14] In patients with HH VF loss, placing the prism edge closer to the border of the residual field acts as a noxious stimulus, alerting them to scan into their non-seeing VF. Inattention to the non-seeing field is more of a problem with those who suffer from acute VF loss. The fitting goal, as stated by Perlin and Dziadul,[14] is to increase the prism power to allow more image displacement and place the prism edge as close as possible to the residual field. Increasing the prism power and changing prism placement allows the patient to enter the prism sooner and receive information more quickly. This modification process entails a few re-fits over the course of several weeks. At the time that Perlin and Dziadul's theory was created, the inpatient program at the EBRC allowed ample time to manipulate the fit and prism power. With time, experience, and a truncated inpatient program, one of the authors (Gagnon) modified the prism power and placement of the fit. She found that a 25-diopter prism placed at approximately 18 degrees for constricted-field patients served as a nice compromise to accommodate an abbreviated

Table 2. How to Measure and Fit Fresnel Prism

Step 1	Ensure that the patient is wearing their spectacle correction and it is fit and adjusted properly to their face to maintain vertex distance. The patient is appropriately placed 1 meter from the tangent screen. If the patient has habituated to a head turn, allow them to maintain this head position. Educate the patient to keep their head still for the remainder of the fitting. They will only need to make eye movements to view targets. Any head movement will alter the fit and prolong the process. For a binocular fit, the central fixation target is directly aligned before the cyclopean eye, in the middle of the patient's head. For a monocular fit, the central fixation target is directly before the seeing eye.
Step 2	Adhere a 1" x 1" piece of tape 18 degrees to the right or left of the central fixation target on the tangent screen (depending on which gaze direction you want to fit first). For this example, we will start with right gaze. Tape is placed 18 degrees to the right of the central fixation target.  To start the fit in right gaze, occlude the OS by placing a Bernell clip-on occluder over the spectacle lens. (A Bernell clip-on occluder should be used as it does not alter the vertex distance.) Instruct the patient to move only their eyes to the right side of the tangent screen and fixate on the piece of 1" x 1" white tape that has been placed at 18 degrees to the right of fixation.

Step 3	With the patient fixating, the doctor will move a piece of surgical tape or Post-It note in from the temporal side as close to the spectacle lens as possible and instruct the patient to say when the white tape (on the tangent screen) disappears. When the patient states that the white tape has disappeared, stick the tape/Post-It note vertically against the front surface of the lens. 
Step 4	Check the ocular rotation of the OD by removing the tape on the tangent screen and asking the patient to fixate on the central circular white target attached to a black wand. Move the wand (with the target attached) horizontally into right gaze, and ask the patient to follow it out with their eyes while holding their head still and state when it disappears. 
Step 5	The target should disappear at ~18 degrees but may be off 1-2 degrees. Make a note of the ocular rotation to ensure that the OS ocular rotation matches the OD.
Step 6	Replace the white tape on the tangent screen at 18 degrees to the right of the center of fixation. Occlude the OD. Move the piece of surgical tape in from the nasal side on the OS, and instruct the patient to tell you when the white tape (on the tangent screen) disappears. Adhere the tape on the front surface of the lens.
Step 7	Check the ocular rotation of the OS by removing the tape on the tangent screen and asking the patient to fixate on the central circular white target attached to a black wand. Move the wand (with the target attached) horizontally into right gaze, and ask the patient to follow it out and state when it disappears. It should disappear at approximately the same ocular rotation in degrees as measured for the OD (1-2 degrees difference between the two eyes is allowed. If there is more than a 2-degree difference, you will need to stabilize the patient's head position and repeat steps 2-7 until both eyes are within 1 to 2 degrees of each other.
Step 8	Remove the Bernell clip-on occluder from the OD. Ask the patient to keep both eyes open and follow the circular white target attached to the black wand into right gaze. Instruct the patient to report when the target disappears. When the patient states that the target has disappeared, alternately occlude the OD and then the OS to ensure that each eye cannot see the target.
Step 9	If the patient can see the target with an eye, the doctor can: 1. Move the tape in closer (in the direction towards the center of the spectacle lens) to "tighten the fit" over the eye that was seeing the target, OR 2. Move the tape farther away from the center of the lens to "loosen the fit" over the eye not seeing the target.

Step 10	Measure the ocular rotation of each eye separately by occluding the OS first. Instruct the patient to tell you when the moving target disappears. Once it disappears, place the target where they can see it, and then move it back out until they state that it has disappeared again. Take note of this ocular rotation.
Step 11	Occlude the OD now. Instruct the patient to tell you when the moving target disappears. Once it disappears, place the target where they can see it, and then move it back out until they state that it has disappeared again. Take note of this ocular rotation.
Step 12	The angle of ocular rotation OD and OS should match or come within 1-2 degrees of each other. If they do not match, shift the tape on the lenses in order to equalize the ocular rotations.
Step 13	Re-check the ocular rotation between the two eyes and ensure synchronicity.
Step 14	Repeat the same procedure for left gaze.
Step 15	If fitting a HH VF loss, repeat steps 1-13, except place 1" x 1" white tape at 5 degrees to the left or right of fixation on the tangent screen based on the side of the HH VF loss. You will fit both eyes (i.e., if left HH VF loss, fit the patient when looking at the white target to the left of fixation, and if right HH VF loss, fit the patient when looking at the white target to the right of fixation. 

inpatient program, yielding the best clinical results for patient acceptance and function.

Procedure for Fitting Fresnel Prisms

The technique for appropriate placement of Fresnel prisms is outlined in Table 2.[21] After the fitting, the Fresnel prisms will be cut and adhered to the spectacle lens. Ensure that the base of the prism always faces the VF defect (i.e., temporally, use base out; nasally, use base in). When cutting the prism, ensure a clean cut between the base and apex of 2 adjacent prisms (Figure 4).

Additionally, leave a little extra prism in case of error so you can trim as necessary instead of cutting an entirely new prism. During the fitting process, the tape is stuck to the front of the spectacle lens (Figure 5). Customarily, sectoral Fresnel prism is worn on the back of the lens. Therefore, the center thickness of the lens will need to be adjusted by moving the prism edge inward by 1 mm (toward the optical center) when moving the tape to the back of the lens. Make a vertical line down the lens with removable marker so that you can remove the tape (Figure 6).

Cut the prism to fit shape of the lens (Figure 7). If the patient wears an add, the prism must be taken out of the add. Once the prism has been cut, adhere the Fresnel by placing water on surface of lens and pressing the Fresnel prism on the lens in an outward direction to remove any bubbles that may be trapped between the lens and prism. Allow 15-20 minutes to dry.

Once the prism is placed, re-test the ocular rotation of each eye in each direction of gaze. Ask the patient to follow the target with both eyes open into right gaze and state when the target disappears. Once it disappears, alternately occlude each eye to ensure that the patient cannot see target with either eye. Occlude one eye, place the target where patient can see it, and move the target until it disappears. Record the ocular rotation. Then, occlude the other eye, place the target where the patient can see it, and move the target until it disappears. Record the ocular rotation for this eye. Make sure the ocular rotations are within 1-2 degrees of each other. If

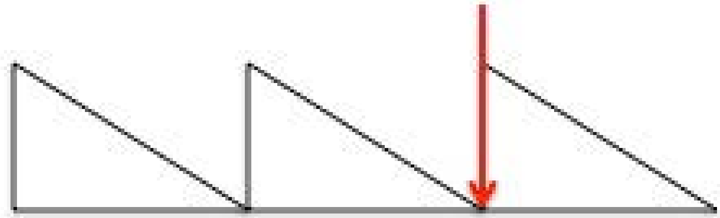


Figure 4. *Press-on Fresnel prism comprising tiny 1-mm prisms. When cutting prism, cut at red arrow (between the base and apex of 2 adjacent prisms).*

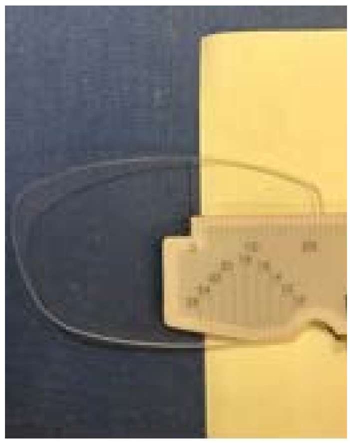


Figure 5 (left). *Tape on front surface of spectacle lens*
Figure 6 (right). *Tape will be transferred to the back of the spectacle lens and moved inward 1mm (toward optical center) to account for center thickness. A vertical line is drawn on the lens with removable marker. (The lens is centered on the yellow Post-It note in the picture to allow for better visualization.)*

they are not, cut some prism over one eye and repeat ocular rotation testing. Repeat for left gaze.

Introduction Prism Training

Once the patient has been fit with sectoral Fresnel prisms, it is imperative for the patient to embark on comprehensive prism therapy training. Comprehensive training will require the optometrist fitting sectoral Fresnel prisms to collaborate with other professionals and provide access to care with interdisciplinary referrals. In the VA system, all professionals are normally located in-house, which makes the referral and training process easier. In the private sector, whether or not the patient meets the criteria to satisfy eligibility for state services, the optometrist will need to refer to O&M specialists and may also need to refer for additional training on image displacement, appreciation and avoidance of the blind spot scotoma, and proper scanning techniques with any of the following: OT, CLVT, or VRT. Optometrists can reach out to the blind association in their respective states to set up a mutual referral program with an O&M specialist, OT, CLVT, or VRT in that area. Considering that the blind association

Figure 7. *Line up the edge of the Fresnel prism with the vertical line drawn on the lens with removable marker. Cut the Fresnel prism to fit the shape of the lens.*

for each state may be different, the optometrist can also consult The American Foundation for the Blind (www.afb.org). This is a national organization that can serve as a resource to help locate these rehabilitation specialists in specific regions who may be able assist patients with O&M training coupled with prism therapy training. This recommended continuum of care for training has been designed to provide the highest standard of care, ensuring safe, efficient, and independent travel without a risk for harm while using the prism. It is only after these skills have been proficiently demonstrated by the patient and confirmed by the O&M professional that the optometrist will dispense the spectacle-mounted sectoral Fresnel prism prescription for full-time wear.

Training with the Optometrist/CLVT/VRT/OT

At the EBRC, prism training begins immediately after the optometrist has completed the fit. A practical trial is performed with the patient while wearing the sectoral Fresnel prisms to demonstrate the basic principles, concepts, and adverse effects of the prism. The patient is brought into a long non-busy hallway and is taught how to gather peripheral information from their non-seeing field quickly by scanning their eyes briefly into the sectoral prisms. The optometrist asks the patient to look straight ahead through the central non-prismatic portion of the spectacle lens while the optometrist walks forward along one side of the patient. The patient should alert them once the optometrist comes into view. Typically, the optometrist is not detected until they are several feet alongside the patient. This same step is repeated, but now the patient is told to scan into the prism while the optometrist walks forward alongside of them. The patient will detect the optometrist within a foot or two. The patient appreciates that with a small eye excursion into the sectoral Fresnel prisms, a target from their non-seeing field can be detected sooner and without the need for a large head sweep. Next, the patient is made aware of the image degradation that occurs when looking through the prisms. However, they are reminded that images seen through the prisms are meant to alert them to a potential hazard in their non-seeing field. If they need to identify or to obtain clarity of a target, they will need to turn their nose toward the target and view through the carrier (non-prismatic portion) of the lens. Image displacement is further explained and demonstrated to the patient. Patients will often recognize and describe a "crowding effect" caused by the displacement of images. Images seen through the prism are displaced from the objects' true positions in space and appear to be encroaching/crowding into their central seeing field. At first, this can be disturbing and bothersome to the patient, especially when walking through doorways or turning corners in a corridor, as the walls appear to be coming out at them. They will tend to misjudge space and make wide turns. However, it is emphasized that with training and practice, they will be able to adjust and to determine the true position of objects in space accurately. The blind spot scotoma is also demonstrated to the patient by having them follow a target and report when it disappears as it is moved from the non-prismatic central portion of the spectacle lens to the edge of the sectoral prism. Once the object disappears, the patient is shown how to compensate for this scotoma and regain the object again by either moving their eyes further into the prism to avoid the edge or by turning their head to remain in the non-prismatic portion of the spectacle lens. After the optometrist completes this practical trial, the patient is ready to undergo more in-depth prism training to ensure that the patient can understand and demonstrate the skills needed to use and compensate for the adverse effects of the prism efficiently. Additionally, the importance of developing proficient scanning skills while using the Fresnel prisms is emphasized. Adopted from an instructional program for Fresnel prism therapy by Brilliant,[23] the required training is sectioned into four parts and is outlined below. This training can be completed by any of the following professionals: optometrist, OT, CLVT, or VRT.

Part 1: Patient stable, object stable

The goal of part 1 is to have the patient successfully spot an object in their periphery using the prisms. Special care is taken so that the patient can appreciate the amount of image displacement caused by the prisms. By the end, the patient should be able to judge displacement accurately 100 percent of the time. The instructor starts by sitting across from the patient and holding a pen/pencil in the temporal periphery. Using the prism, the patient is asked to point to where they think it is located. While maintaining this position, the patient looks through the carrier portion to ascertain the actual location of the object. Initially, the patient will point more nasally, but with repeated practice, the patient will learn to appreciate the actual displacement.

Part 2: Patient stable, object moving

The goal of part 2 is to have the patient successfully grab an object moving at a constant speed in their periphery. Similar to part 1, the instructor asks the patient to view an object through the prisms while it is being moved, and the patient is asked to grab the object when the instructor says "now." The patient should not be allowed to advance to part 3 until they achieve 100 percent accuracy.

Part 3: Patient moving, object stable

The goal of part 3 is to have the patient appreciate making swift eye movements into and out of the prisms to identify stationary objects or doorways. The ideal environment would be a long hallway with several doorways or a hallway with obstacles. The patient should walk down the hallway, viewing through the carrier portion and intermittently scanning into and out of the prism to pick up peripheral targets. The patient will graduate from this part once they are able to identify doorways or objects quickly and accurately by scanning into the prism.

Part 4: Patient moving, object(s) moving

The last part of training involves incorporating all parts together. After completing part 4 of training, the patient should be able to maneuver safely within a complex indoor environment like a congested hallway or store aisle while using the prism. The goal is to ensure that the patient does not bump into any obstacles or people.

While the EBRC is a comprehensive inpatient program that has the resources to offer extensive prism therapy training, this may not be an option for most patients. Even if patients are not enrolled in an inpatient training program, they should still receive comparable prism training as outlined in this section. This training can be provided solely by the fitting optometrist, or if that option is not feasible, then patients should be referred to any of the following rehabilitation specialists: an OT, CLVT, or VRT.

Training with an O&M Specialist

The O&M specialist plays an integral role in sectoral Fresnel prism VFET. As previously stated, before a patient can undergo a sectoral Fresnel prism fitting, they must be deemed an ideal candidate, which requires that the patient be able to demonstrate proficient mobility and long white cane skills. This ensures that the patient has adequate knowledge and can efficiently use their mobility skills prior to using Fresnel prisms. Therefore, even if the patient appears to be an ideal candidate from the optometric standpoint, the patient will need to be referred for an O&M evaluation and training to confirm proficient mobility skills. The initial O&M evaluation will entail an indoor and an outdoor mobility assessment, as well as determination of fall risk. This alerts the instructor to the level of mobility skills and the efficiency of scanning techniques. Once the assessment is complete, the instructor will introduce the long white cane and teach basic cane skills and techniques. The instructor will also reinforce scanning techniques while using the long white cane. Training will begin in a non-crowded area, where the patient will learn to detect doorways and other obstacles. Patients will learn to use the long white cane to detect changes in terrain and detect objects at floor level. This proprioceptive feedback of the inferior field provided by the cane allows the patient to keep their visual attention on the horizon directly in front of them.[12] Training continues with basic environments and progresses into incorporating busy environments with multiple people and objects. After the patient has completed the initial assessment and training and is deemed by the O&M specialist to be proficient with respect to their mobility and long white cane skills, the patient is now ready to undergo the sectoral Fresnel prism fit with the optometrist.

Once the patient has been fit with the prism and has undergone training with the optometrist, the optometrist will give the O&M specialist the sector Fresnel prism spectacle prescription to use during O&M training. Fresnel prism therapy can now be introduced in conjunction with the long white cane to help locate peripheral objects sooner.[12] Of note, the prism prescription is not dispensed by the optometrist directly to the patient until O&M training using the prism has been completed. The O&M specialist will aid in the prism therapy training by teaching the patient to use the prism in combination with their long white cane in real-world scenarios. During prism therapy training, patients are reminded to scan into the sectoral Fresnel prisms to locate peripheral objects and then scan out of the prisms to use the carrier portion to maintain object location accuracy. With completion of this training and demonstration of proficient skills to ensure that the patient can safely and independently travel while using sectoral Fresnel prisms without a risk of harm, the prism prescription is dispensed for full-time wear.

Case Demonstrating Application

Traditional Fit

Case Report #1

A 56-year-old Caucasian male presented for his initial low vision evaluation. He presented with complaints of missing objects on his left side. The patient reported that he noticed this symptom approximately 6 months prior to his most recent CVA. The patient stated that he was scanning more to his left side to compensate. Although these eye scanning movements helped, he still felt hesitant and insecure while traveling. His ocular history was remarkable for an incongruous left HH with macular sparing, compound hyperopic astigmatism OD, emmetropia OS, and presbyopia OU. Systemic history was remarkable for three CVAs, hypertension, and hypercholesterolemia. His current medications included Prestor, Norvasc, Celexa, levothyroxine, and warfarin.

Entering corrected distance visual acuity (DVA) with the patient's habitual prescription was +1.00 -0.50x110 (20/20) OD and +0.25 sphere (20/20) OS. Cover test at distance revealed orthophoric posture, and the patient denied any diplopia or asthenopia. Refraction revealed +1.25-0.75x110 OD and plano OS with stable visual acuity and only a mild subjective improvement in clarity OD. After performing a tint evaluation, the patient preferred 90% transmission plum for indoors and 30% transmission amber for sun wear prescription. Automated 30-2 Humphrey VF testing had been performed at his most recent comprehensive eye exam in the General Optometry Clinic. The VF revealed a left incongruous HH with macular sparing OD>OS and showed ~5-10 degrees macular sparing OD and ~5 degrees inferior macular sparing OS (Figure 8).

Based on the selection criteria for a Fresnel prism fit, this patient was identified as a good candidate. The patient had a HH VF defect with macular sparing, had

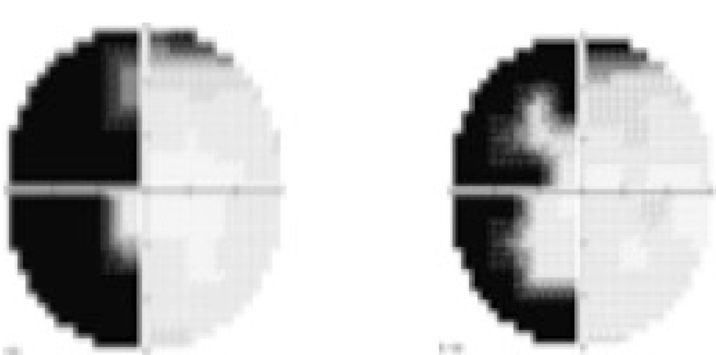


Figure 8. *Humphrey visual field 30-2 showing left HH with macular sparing OD > OS*

Figure 9 (left). *Press-on Fresnel prism*
Figure 10 (right). *Press-on Fresnel prism highlighting the 1mm multiple prisms that make up a press-on Fresnel prism.*

no indication of cognitive deficits based on a post-stroke evaluation from his primary care physician (PCP), and was highly motivated to learn how to use Fresnel prisms successfully. When the concept of prism was explained and demonstrated, the patient had a full understanding and was interested in proceeding with the prism fit and training requirements. The patient was referred to the O&M specialist for a mobility assessment and long white cane training. Once this training was completed and the O&M specialist deemed the patient proficient with mobility and long white cane skills, the patient returned to the LV clinic to complete a sectoral Fresnel prism fit.

Using a tangent screen, the patient was fit using the traditional Fresnel prism protocol recommended for HH VF with macular sparing. A 25-prism diopter Fresnel prism was fit to the spectacles with the bases orientated toward the side of the VF defect, which in this case was to the left (base out over OS and base in over OD). The prism edge was placed on the spectacle lens to allow for a 5-degree ocular rotation in OD and OS before entering the prism. Verification of ocular rotation for each eye confirmed that each eye entered the prism at the same time to avoid diplopia. After the fit was completed, training was initiated in office. A practical trial was performed while the patient was wearing the sectoral Fresnel prisms to demonstrate the basic principles, concepts, and adverse effects of the prism. The patient then received further training on these concepts by the EBRC CLVT. The spectacles with the mounted sectoral Fresnel prisms were given to the O&M instructor to complete mobility and long white cane skills while using the prisms.

During mobility training with the O&M specialist, the patient expressed concern that the prism edge was disruptive and was interfering with his central vision when viewing through the carrier. This indicated that the prism edge OU was fit too close to the patient's central vision and needed to be readjusted to allow for a slightly larger ocular rotation. The prism was re-fit and adjusted OU. One prism, or approximately 1 mm of press-on Fresnel prism, was removed (Figures 9 and 10). After cutting the prism to increase ocular rotation, the verification process was repeated. The resulting ocular rotation was ~7-8 degrees in both OD and OS, and the patient stated that he no longer felt that the prism edge was interfering with his central vision. The patient successfully completed a 6-session training program (2-hour visits, 3 times per week, for 2 weeks) using the long white cane with Fresnel prisms. At the end of the training period, the patient successfully demonstrated proficiency scanning into the prism, as well as verifying object placement using the carrier portion of the spectacles. The patient was satisfied with the prism and felt more comfortable navigating familiar and unfamiliar environments with confidence.

Case Report #2

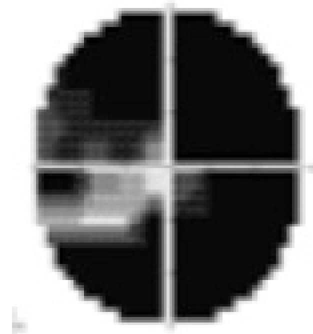
A 55-year-old African American male presented for a second time to the EBRC reporting increased mobility difficulties since his last admission approximately 2 years prior. He complained of bumping into people and objects more often in the last few months. During his previous stay at the EBRC, the patient received comprehensive O&M and white cane training. Additionally, he was prescribed a 2.5x Selsi hand-held monocular telescope for distance spotting and a 1.7x full-diameter telescope used in reverse to help increase his peripheral awareness. Even with comprehensive O&M and low vision aids, the patient stated that he was still having mobility difficulties.

The patient's systemic history was remarkable for hypertension, hyperlipidemia, and gallstone pancreatitis. His ocular history consisted of end-stage primary open-angle glaucoma OD>OS status-post trabeculectomy and argon laser suture lysis OS, legal blindness, dry eye syndrome, and a history of trauma

OD. His current systemic medications included acetaminophen 325 mg, atorvastatin calcium 80 mg, and chlorthalidone 25 mg. Ocular medications included Simbrinza 1%-0.2% TID OU, timolol 0.5% BID OU, latanoprost 0.005% QHS OU, methazolamide 50 mg TID PO, and carboxymethylcellulose PF 0.5% QID OU.

Entering distance visual acuity with the patient's habitual prescription was NLP OD and +2.25 sphere ($20/40^{-2}$) OS. Pupils were equal and reactive with an afferent pupillary defect OD. Extraocular motility was full in all quadrants with no constriction OU. Slit lamp examination revealed meibomian gland dysfunction OU with the presence of superficial punctate keratopathy OD>OS and mild cataracts OU. Intraocular pressures measured 12 mmHG OD and 13 mmHG OS. Dilated fundoscopy revealed a cup-to-disc ratio of 0.99 with pallor OD and 0.95 with slight superior rim remaining OS. The macula, retinal vasculature, and periphery were all within normal limits OU. A tint evaluation was performed, and the patient preferred 70% transmission amber for indoors. An automated 10-2 Humphrey VF OS was performed and showed dense 360 constriction with a small inferotemporal island of vision (~6 degrees) remaining (Figure 11). A tangent screen was also performed to gain better insight into the amount of functional field remaining OS. The tangent screen tested at 1 meter with a 5 mm target size showed ~5 degrees of field remaining nasally, ~4 degrees of field remaining superiorly and inferiorly, and ~18 degrees remaining superior temporally (Figure 12). Based on the selection criteria for a Fresnel prism fit, this patient was identified as a potential candidate. The patient had constricted VF loss, was highly motivated, had a need to travel independently, had no cognitive deficits, and was already proficient with a long white cane.

Given that the patient was NLP OD, this patient was fit monocularly. On the nasal side, the patient was severely constricted; however, on the temporal side, the patient had a larger amount of field remaining. His remaining VF shared features of both a midline cut and an overall constricted VF. Therefore, the customary protocol to fit hemianopic field loss was performed nasally, and the customary protocol to fit a constricted field loss was performed temporally. After trialing in office, the final ocular rotation was approximately 10 degrees nasally and approximately 16 degrees temporally. Prism placement on the nasal side of the OS was originally fit following the



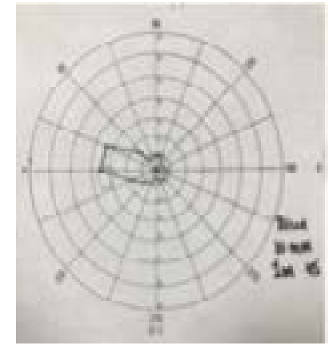


Figure 11 (left). *Humphrey Sita Standard 10-2 visual field showing small inferotemporal island of vision remaining (approx. 6 degrees)*
Figure 12 (right). *Tangent screen at 1 meter showing temporal island of vision remaining (approx. 18 degrees superior temporal and temporal)*

criteria for HH VF loss at approximately 5 degrees. However, the prisms were moved slightly further out, as the patient felt that they were encroaching on his remaining central field.

Since the patient was already proficient in his mobility and long white cane skills, he completed a truncated prism therapy program, incorporating the use of the prisms with his long white cane. Using a functional VF assessment, trialed in the hallway, the patient had a drastic increase in field awareness. At the end of the program, the patient was very satisfied with the prism fit and continues to use his Fresnel spectacles daily. This patient significantly appreciated the optical shift from the sectoral Fresnel prisms, which provided him peripheral information sooner, obviating significant head sweeps. Although this patient's functional mobility performance improved significantly by combining sectoral Fresnel prism therapy with his long white cane and mobility skills, similar patients will learn to compensate with just proper O&M training and may not benefit any further with Fresnel VFET.

Conclusion

Patients with advanced PVF loss, whether HH or overall 360-degree constriction, may suffer from various degrees of risk when ambulating. These patients are susceptible to having falls and serious injuries. Many also experience a decreased quality of life due to limits on ADLs and social, occupational, and recreational activities. Neglecting to evaluate, treat, and/or refer the patient for their functional deficits from PVF loss can result in significant visual inability and risk. However, advanced PVF loss brings a unique set of challenges to optometrists. This subset of patients demands a certain skill set for which optometrists are uniquely trained and poised to recognize and subsequently to provide effective treatment options, including appropriate referrals. Inarguably, optometrists are specifically trained and qualified to address such deficits and are at the epicenter of treatment. It is to this end that this article was written, reviewing for the LV optometrist or presenting to the inquisitive primary care optometrist, methods to serve our potentially underserved and at-risk patients with PVF loss.

Sectoral Fresnel prism therapy is one such treatment used by optometrists to enhance peripheral field awareness in those patients suffering from advanced HH and overall constricted VF loss. Fresnel prism therapy has many benefits, including the ability to displace images from the patient's non-seeing field into the patient's seeing field. This allows patients to get peripheral information sooner about potential hazards, preventing injuries or falls while obviating the need for large head sweeps. Sectoral Fresnel prisms widen the amount of territory that a patient can survey using smaller, more comfortable eye excursions. With the help of Fresnel prisms, patients become more proficient scanners and feel more secure when traveling independently. These benefits provide patients with an opportunity to compensate for their debilitating VF loss, improve overall visual function, and consequently improve quality of life.

Choosing an appropriate candidate and providing comprehensive training with an interdisciplinary approach is critical for ensuring immediate and continued success with Fresnel prisms. Nevertheless, even if a patient does not meet the criteria for an ideal candidate, the patient may still benefit and excel with sectoral Fresnel prisms. Do not discount the more non-conventional cases. Modifications to the standard recommended prism placement and power may improve success in both conventional and non-conventional Fresnel fits. The optometrist can increase or decrease the prism power or alter prism placement depending on how the patient responds in office. Do not get discouraged if the fit is not perfect on the first visit. A successful Fresnel fit may require additional visits to make the necessary modifications. While every fit may not be successful, the optometrist is equipped with the necessary tools and knowledge to give the patient the best chance for success.

Although there is no standardized protocol for fitting Fresnel prisms, optometrists can use this guide to fit patients. The intent of this paper is to share with optometrists a stepwise evaluation and fitting model for prescribing sectoral Fresnel prisms in patients with significant PVF loss. This outlined method has been refined and derived from clinical expertise and years of experience with fitting sectoral Fresnel prisms at the WHVA. This protocol empowers and arms optometrists with the skills necessary to fit sectoral Fresnel prisms systematically using a standardized protocol that can be repeated and has been proven clinically successful at WHVA. However, it will require commitment and a minimal investment in a tangent screen. Although we have the luxury of time at the EBRC in WHVA, this setting has provided a number of LV optometrists the opportunity to put this method to the test, honing and modifying the process through the help of our patients' perceptions, abilities, and outcomes. We believe that this model, when embraced and practiced, can successfully be implemented in a number of optometric practices and settings. Preventing the psychosocial implications from debilitating PVF loss will require an investment from both the patient and the optometrist.

References

1. Rowe FJ, Wright D, Brand D, et al. A prospective profile of visual field loss following stroke: Prevalence, type, rehabilitation, and outcome. Biomed Res Int 2013;2013:719096.
2. Ward ME. Anatomy and physiology of the eye. In: Corn AL, Koenig AJ, eds. Foundations of low vision: Clinical and functional perspectives. New York, NY: AFB, 1996.
3. Kuyk T, Elliot JL, Biehl J, Fuhr PS. Environmental variables and mobility performance in adults with low vision. J Am Optom Assoc 1996;67:403-9.
4. Hardiess G, Papageorgiou E, Schiefer U, Mallot H. Functional compensation of visual field deficits in hemianopic patients under the influence of different task demands. Vis Res 2010; 50:1158-72.
5. Tallman KB, Haskes C, Perlin RR. A case study of choroideremia highlighting differential diagnosis and management with Fresnel prism therapy. Optom 1996;67:421-9.
6. Chea C, Marinoff R. Case Reports: The use of sector Fresnel prism for increased peripheral visual field awareness for patients with end-stage retinitis pigmentosa and glaucoma. Optom Vis Perform 2015;3(4):197-202.
7. Schmiedecke S, Jose R. Prism therapy in low vision rehabilitation. Int Congress Series 2005;1282:709-13.
8. Jose RT. Understanding Low Vision. New York: American Foundation for the Blind, 1983.
9. Haymes S, Guest D, Heyes A, et al. Mobility of people with retinitis pigmentosa as a function of vision and psychological variables. Optom Vis Sci 1996;73:621-37.
10. Hassan SE, Hicks JC, Lei H, Turano KA. What is the minimum field of view required for efficient navigation? Vis Res 2007;47(16):2115-23.
11. Cohen JM. An overview of enhancement techniques for peripheral field loss. Optometry 1992;63:60-70.

12. Finn W, Gadbaw P, Kevorkian G, De L'Aune W. Increased field accessibility through prismatically displaced images. The New Outlook 1975;465-7.
13. Hoppe E, Perlin RR. The effectivity of Fresnel prism for visual field enhancement. Optom 1993;64:46-53.
14. Perlin RR, Dziadul J. Fresnel prisms for field enhancement of patients with constricted or hemianopic visual fields. Optom 1991;62:58-64.
15. Giorgi RG, Woods RL, Peli E. Clinical and laboratory evaluation of peripheral prism glasses for hemianopia. Optom Vis Sci 2009;86(5):492-502.
16. Jose R, Smith A. Increasing peripheral field awareness with Fresnel prisms. OJRO 1976;33-7.
17. Gadbaw P, Finn W, Dolan M, De L'Aune W. Parameters of success in the use of Fresnel prisms. OJRO 1976;41-3.
18. Bailey IL. Prismatic treatment for field defects. Optom Monthly 1978;69(14):99-107.
19. Rundstrom MM, Eperjesi F. Is there a need for binocular vision evaluation in low vision? Ophthal Physiol Opt 1995:15(5):525-8.
20. Bhola R. Binocular Vision. EyeRounds.org. Jan 23, 2006; Available from http://eyerounds.org/tutorials/Bhola-BinocularVision.html.
21. Lee AG, Perez AM. Improving awareness of peripheral visual field using sectorial prism. J Am Optom Assoc 1999;70:624-8.
22. The Fresnel Prism & Lens Co. What is a Fresnel Prism Lens [cited June 16, 2019]. Available from https://www.fresnel-prism.com/what-is-a-fresnel-prism-lens
23. Brilliant R. Essentials of Low Vision Practice. Massachusetts: Butterworth-Heinemann, 1999.

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Small M, Zerilli-Zavgorodni T, Shenouda-Awad N, Gagnon KG. Increasing peripheral visual field awareness using sectoral Fresnel prisms: Review of a model for step-wise evaluation and fitting. Optom Vis Perf 2021;9(2):87-104.