Article ▸ Case Reports: The Use of Sector Fresnel Prism for Increased Peripheral Visual Field Awareness for Patients with End-Stage Retinitis Pigmentosa and Glaucoma

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ABSTRACT

Background: Peripheral field loss from conditions such as retinitis pigmentosa and glaucoma can cause significant disabilities by limiting activities of daily living. Severe peripheral field loss causes mobility difficulties with activities such as identifying and adapting to obstacles in the environment. It can also cause emotional strain and impair quality of life. Because this visual field loss is often slow and progressive, patients may be unaware of these functional implications. In addition to orientation and mobility training, sector Fresnel prism therapy is a complementary visual field awareness technique to help the patients obtain information from the missing field.

Case Reports: Two cases are presented with the characteristic functional impairments of severe overall visual field constriction. The first case involves a 58-year-old male with advanced retinitis pigmentosa. The second case is of a 52-year-old male with advanced primary open-angle glaucoma.

Conclusion: The use of sector Fresnel prism to improve mobility and spatial awareness has long been a clinically accepted tool for rehabilitating patients with overall constricted peripheral visual fields. The prism reduces the degree of eye movement needed to detect peripheral objects in the environment. With in-office training and mobility training, sector Fresnel prism can be successful in helping the patients increase their peripheral awareness of objects, improve their navigational ability, and improve their quality of life.

Keywords: end-stage glaucoma, Fresnel prism, low vision rehabilitation, retinitis pigmentosa, visual field awareness, visual field constriction

Introduction

Peripheral field loss can result from ocular diseases such as retinitis pigmentosa (RP), glaucoma, choroideremia, and gyrate atrophy. This paper will discuss two patients, one with end-stage retinitis pigmentosa and one with end-stage primary open-angle glaucoma. Both conditions gradually progress to severe visual field constriction. The typical pattern of field loss from RP begins as a mid-peripheral ring scotoma that expands outward to constrict the peripheral field and finally affects central vision at the end stage.[1] In contrast, the field loss from primary open-angle glaucoma follows three major patterns: diffuse decrease in sensitivity, especially in the periphery, that is typical of ischemic high-pressure glaucomas; a scotoma involving areas 15 degrees from fixation that is typical of chronic, moderate-elevated glaucomas; and a paracentral scotoma that is typical of glaucoma with normal levels of intraocular pressure (IOP).[2] In both cases, the initial visual field loss usually occurs in the mid-peripheral and peripheral areas.

The peripheral retina has a high concentration of rod photoreceptors. There are approximately 110-130 million rod photoreceptors that are responsible for night vision and detecting movement. In contrast, the macula has the highest concentration of cone photoreceptors. These six million cones are primarily responsible for distinguishing color and fine details.[3] As the peripheral retinal cells are damaged, the peripheral visual field slowly constricts, resulting in functional difficulties with tasks such as locating objects and finding the next word when reading. Since visual field loss from RP and glaucoma is often slow and progressive, patients may be unaware of these functional losses until the disease has reached an advanced stage.

Severe peripheral field loss causes significant disability by limiting activities of daily living. Amongst the greatest concerns is how damage to the peripheral visual system impacts safe and efficient travel. In comparison to patients with acuity loss, those with peripheral field restriction have increased mobility difficulty in both photopic and mesopic conditions.[4] A study by Freeman et al.[5] showed that visual field loss is the primary visual deficit that increases the risk of falling. When comparing central field loss, peripheral field loss, visual acuity, contrast sensitivity, and stereoacuity, only peripheral field loss had a statistically significant association with falls. Another study by Vargas-Martin and Peli[6] illustrated that patients with severe peripheral field loss of less than 15º diameter exhibited reduced horizontal scanning eye movement due to the lack of peripheral

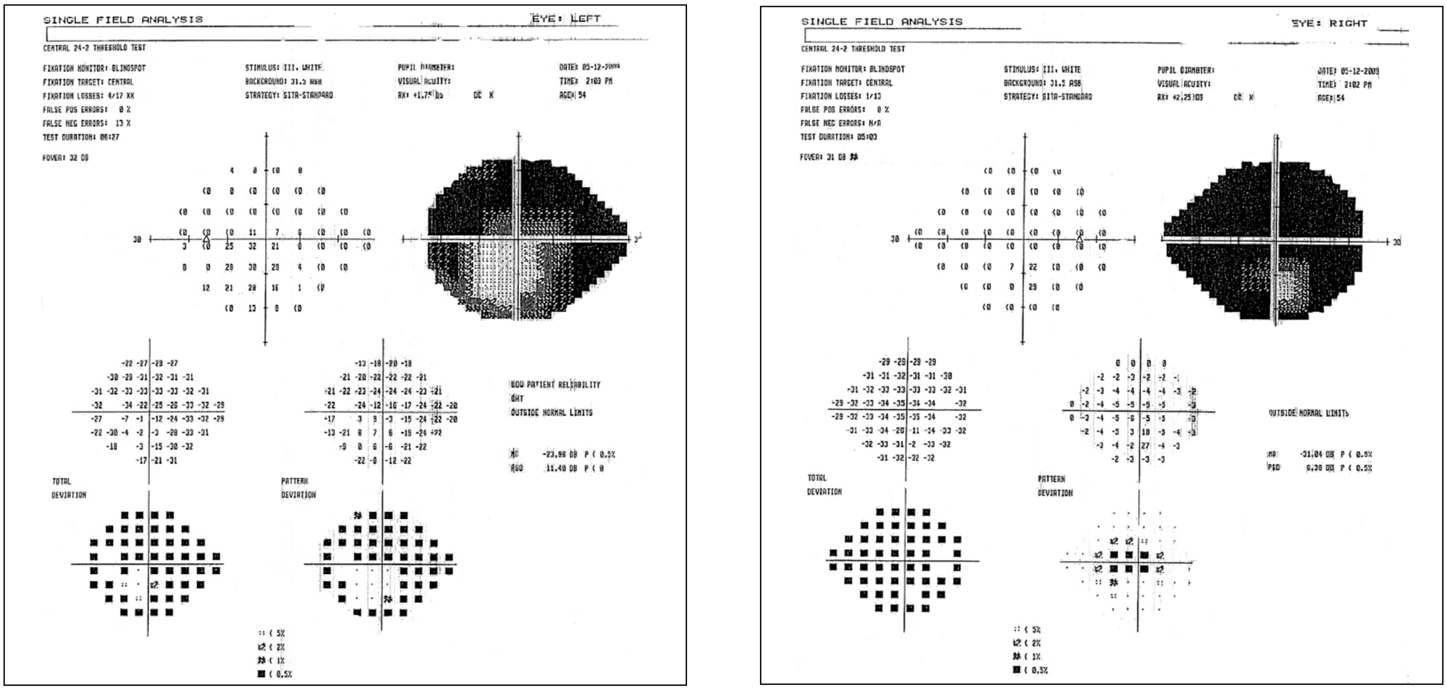

Figure 1. *Humphrey SS visual field 24-2 of the patient with advanced retinitis pigmentosa*

stimulation. Lastly, Graci et al.[7] showed that the ability to plan and to control walking movements in the environment is diminished for those with severe peripheral field loss that encroaches upon central vision. Hence, severe peripheral field constriction could negatively impact navigation.

Moreover, different degrees of field loss impact navigational ability differently. A study by Hassan et al.[8] found that the minimum field of view required for efficient navigation is dependent on the contrast level of the environment; a larger field of view is needed to navigate efficiently in a poor-contrast environment, while a smaller field of view may be sufficient to navigate in a high-contrast environment. Many other studies generated the common consensus that the size of the patient's visual field and the contrast sensitivity measurements are significant predictors of their navigational performance.[4, 9-11] Thus, peripheral field loss can detrimentally impair mobility by causing difficulties in identifying and adapting to obstacles in the environment, especially in a dimly lit room.

Severe peripheral visual field loss can also cause emotional strain and reduced quality of life. A Japanese prospective study demonstrated a significant correlation between increased peripheral visual field loss and a lower vision-related quality of life score in forty RP patients.[12] Severe navigational difficulty could result in feelings of isolation and fear of traveling outside the home, causing patients subconsciously to restrict their activities.[13]

These physical, visual, and mental implications make low vision rehabilitation especially important for patients with severe peripheral visual field loss. The overall goal is to teach techniques to navigate safely, efficiently, and independently through different environments. This is important because patients with field constriction experience falling, tripping over stairs and curbs, and bumping into large obstacles such as doorways, furniture, and people. The first intervention is usually orientation and mobility (O&M) training provided by licensed instructors to learn safe, efficient, and effective travelling skills and techniques. "Orientation" refers to knowing where you are and where you want to go, while "mobility" refers to the ability to move from place to place.[14] In addition, low vision optometrists can use complementary visual field awareness techniques to help the patients obtain information from the missing field.

There are two main types of visual field awareness techniques that are used clinically to manage patients with overall field loss. The first type involves minification of the image using reverse telescopes, minus lenses, and amorphic lenses.[15] The intention is optically to create a smaller image to fit into the remaining visual field. However, any degree of minification will result in a proportional loss of visual acuity.

The second type of visual field awareness technique involves the use of sector prism and scanning training. The prism works by optically relocating peripheral objects from the missing field into the seeing field. The goal is to reduce the degree of eye movements needed to scan the environment without decreasing central acuity.[15,16] Sector Fresnel prisms are a relatively easy, temporary, and inexpensive form of prism therapy. Specialty lenses with permanent prisms arranged in different orientations are also available from Chadwick Optical.[a,17] Unfortunately, there are no large-scale clinical studies that compare the effectivity of these different techniques for patients with severe overall peripheral field loss. Depending on clinical experience, clinicians may prefer to use one of the two techniques.

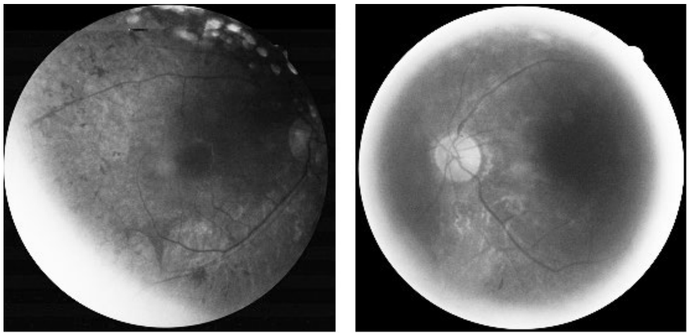

Figure 2. *Undilated fundus photography of Patient 1 with advanced retinitis pigmentosa*

Figure 3. *Sector Fresnel prism mounted onto lenses*

This paper will focus on the low vision rehabilitative management of severe overall peripheral field loss using sector Fresnel prisms to increase visual field awareness. Two cases will be presented involving the use of sector Fresnel prisms to increase awareness of peripheral objects for one patient with advanced RP and another patient with advanced glaucoma.

Case Reports

Case 1

A 58-year-old Asian male with advanced retinitis pigmentosa presented initially to the Low Vision Clinic at the Lighthouse Guild International with complaints of blurry vision and difficulty seeing at night. He worked in a supermarket stockroom located in the basement and would leave work early to avoid traveling after sunset. He was also contemplating early retirement due to bumping into objects and people at work. For treatment, his ophthalmologist had prescribed Vitamin A palmitate 10,000 International Units daily. His medical history consisted of borderline diabetes and borderline hypercholesterolemia without medication. He reported no known allergies to medication or to the environment.

His entering corrected distance acuity was 2m/3M (20/30) OD/OS using the Early Treatment of Diabetic Retinopathy Study (ETDRS) chart.[b] Refraction yielded OD: -0.50 sphere, 2m/3M (20/30) and OS: pl-0.50x015, 2m/3M (20/30). Monocular Amsler grid testing revealed no scotoma or metamorphopsia in the right or left eye. Confrontation visual field testing showed severe constriction in all quadrants in each eye. Contrast sensitivity testing performed with the Mars Letter Contrast Test[c] was 1.32 in each eye, indicating a moderate loss of contrast sensitivity. His ophthalmologist provided a copy of the most recent Humphrey SITA Standard (SS) visual field 24-2 testing, which indicated severe peripheral field loss: the right eye had 6-12° of remaining central field that was displaced inferiorly, and the left eye had 2-5° of remaining central field that extended 20° inferiorly (Figure 1). Anterior segment was unremarkable in both eyes. Undilated fundus examination showed classic features of retinitis pigmentosa: a waxy, pale optic nerve, attenuated arteries, and mid-peripheral bone spicule-shaped pigment deposits in both eyes (Figure 2).

Just prior to this examination, the patient was registered as legally blind with the New York State Commission for the Blind. O&M training was recommended to teach the patient safe and independent navigational techniques. Vision Rehabilitation Therapy (VRT) was also recommended to help with activities of daily living such as personal grooming and cooking.

During the first visit, using spectacle-mounted prisms to increase peripheral field awareness as an adjunct to O&M training was discussed. The patient expressed interest in the prism, and two units of 20^{Δ} Fresnel prism were ordered. One month later, the patient presented for a follow-up visit to pick up his new distance glasses and to trial sector Fresnel prisms. The patient had no additional visual complaints or changes and had started O&M training. We applied a temporal sector of 20^{Δ} Fresnel prism base out (BO) to the limbal margin in each lens, moving it further temporally until there was no interference with vision in primary gaze (Figure 3). The patient underwent training on how to scan using the prism as a compensatory aid. The patient was taught to scan into the side prism and then to turn his head to look directly through the center of the lens. The patient experienced mild disorientation with the prism but was able to complete the training. Instruction was given to practice using the prism at home. Specialty lenses with ground-in prisms were discussed but not pursued due to cost. Because the patient had recently voluntarily retired, he planned to use the prism glasses only at home.

At the third visit one month later, the patient reported that the prism was helpful in detecting gross outlines of peripheral objects and people. He noted increased peripheral awareness and improved mobility. Overall, he reported satisfaction with the prism and planned to continue to use the prism spectacles at home.

Upon his return to the low vision clinic a year later, the patient presented with complaints of reduced near vision and dizziness while walking when using the prism spectacles. It was determined that this was due to excessive scanning into the prism as he was moving his head. As a result, the prisms were moved further temporally on the lenses, away from the visual axis, and additional in-office scanning training was provided. His O&M specialist was also consulted regarding his progress and the possibility of incorporating the prisms into his O&M training program. Because the prisms were significantly improving his navigational ability, the patient decided to begin using the prism spectacles outdoors as well as indoors. A pair of

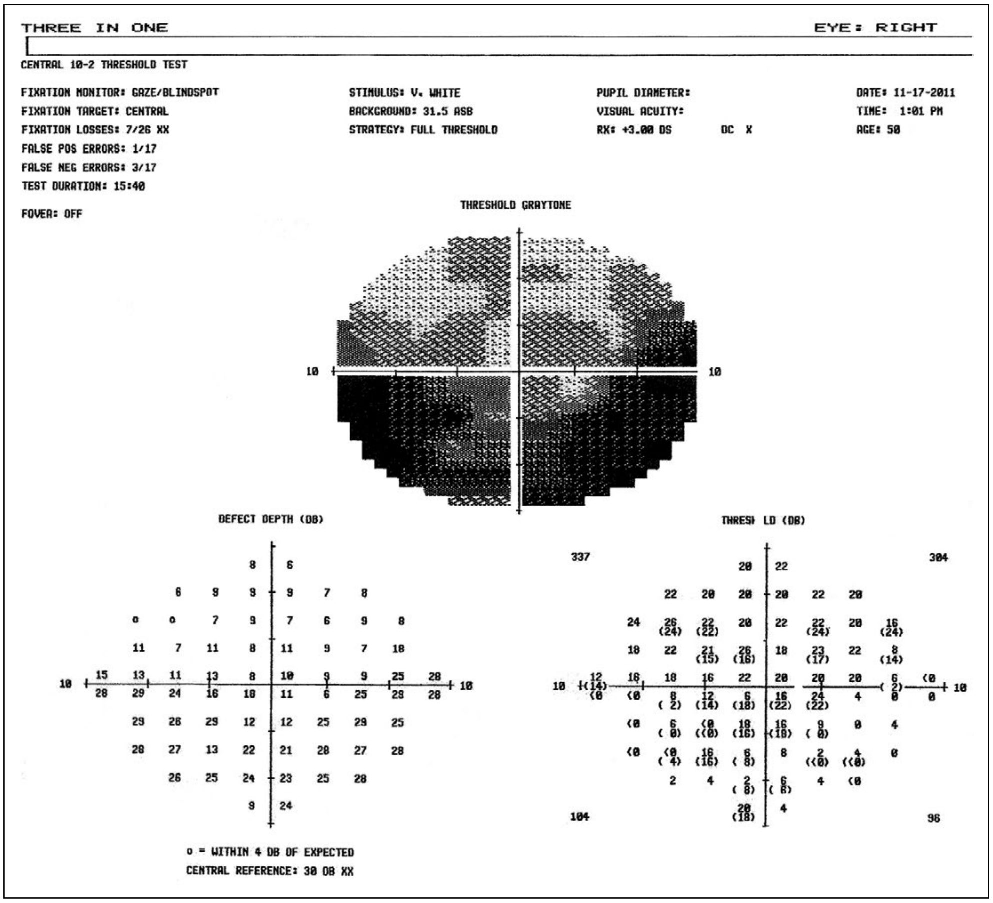

Figure 4. *Humphrey visual field 10-2 using size V white stimulus of the patient with advanced glaucoma*

sunglasses with sector Fresnel prisms was given to the patient for outdoor use.

Case 2

A 52-year-old Asian male with advanced primary open-angle glaucoma presented to the Low Vision Clinic at the Lighthouse Guild International with a complaint of decreased vision OD and occasionally bumping into objects. The patient was registered as legally blind and had received O&M training the previous year. The patient was monitored by a glaucoma specialist who had prescribed Lumigan one drop every night in both eyes, pilocarpine hydrochloride ophthalmic solution 1% one drop four times per day in both eyes, Combigan one drop two times per day in both eyes, Azopt one drop two times per day in both eyes, and acetazolamide 500 mg one capsule two times per day. He reported a history of selective laser trabeculoplasty, laser peripheral iridotomy, and cataract extraction in both eyes, but he was unable to provide dates for when these procedures took place. He was also using artificial tears when necessary and Restasis one drop two times per day in both eyes for moderate dry eye syndrome. Other medications consisted of Vesicare for an overactive bladder. He reported no known allergies to medications but indicated that he was allergic to pollen.

The entering corrected distance acuity was 2m/5M (20/50) OD using the ETDRS chart and no light perception OS. After refraction, his distance refractive error and acuity was measured to be OD: +1.50-0.25x100, 2m/5M (20/50). Contrast sensitivity testing performed with the Mars Letter Contrast Test was less than 1.00, indicating a severe loss of contrast sensitivity. Confrontation visual field testing showed severe constriction in all quadrants OD. The most recent Humphrey visual field 10-2 using size V stimulus revealed severe constriction to approximately 15º vertically and 15-20º horizontally, with greater field loss in the inferior field (Figure 4). Miosis and poor fixation prevented a clear undilated view of his fundus at this visit, but the patient reported follow-up with his glaucoma specialist every 3 months.

In the past, a spectacle-mounted reverse telescope OD was tried without success. When shown a 2.8x hand-held reverse telescope at this visit, the patient noted minimal expansion of his field and disliked the decrease in his visual acuity through the telescope. Sector Fresnel prism was also discussed as an option to increase his peripheral field awareness, and the patient indicated that he was interested. A temporal sector 20^{Δ} Fresnel prism was applied base out to the limbal margin of the right lens, moving it further temporally until there was no interference with vision in primary gaze. Successful training took place in the exam room and hallway with the patient detecting either stationary or moving targets through the prism and then turning his head to look at the targets through the middle of the lens. The patient did well with the prism and did not experience disorientation and visual discomfort. His only concerns were cosmesis and prism maintenance.

At the six-month follow-up visit, the patient presented with a complaint of blurry vision OD. However, his visual acuity remained unchanged at 2m/5M (20/50). The patient still retained daily use of the prism glasses and reported increased awareness of peripheral objects within the home. He remained very satisfied with the use of the prism and was no longer concerned about the cosmesis. He also reported using the 2.8x reverse telescope sparingly. Due to elevated intraocular pressure in the left eye (14 mmHg OD, 42mmHg OS) measured with a non-contact tonometer, we advised rescheduling a visit with his glaucoma specialist.

Discussion

Both patients had severe peripheral field loss that caused debilitating limitations to their activities of daily living. In particular, mobility problems were a great concern for both patients. To supplement O&M training, sector Fresnel prisms were used to increase awareness of their missing peripheral fields.

The use of sector Fresnel prism to improve mobility and spatial awareness has long been a clinically accepted tool for rehabilitating patients with constricted peripheral visual fields. It works by optically shifting objects from the peripheral environment that are not seen into the remaining central field. The patient is instructed to scan occasionally into the temporal prism then turn his head to look through the center of the lens; this idea is similar to scanning into the side mirrors when driving. During in-office training, the patient remains stationary while scanning for stationary targets and then progresses to looking at moving targets. The second part of the training involves the patient walking down the hallway while looking at stationary targets and then progresses to looking at moving targets. Different numbers on the Designs for Vision Distance Test Chart[d] were used as examples of stationary and moving targets with both patients. Both of our patients showed adequate ability in using the prisms after the first in-office training, so we recommended using the prisms at home only and coming back for a follow-up in a month. This training is crucial to success.

Different practitioners may have different fitting techniques with prisms. With the patients looking at a distance target in primary gaze, a Post-it note can be introduced to the side of the temporal corneal limbus and moved further temporally until the patient is unable to notice it. A strip of 20^{Δ} Fresnel prism is placed base-out in place of the Post-it. A study by Perlin and Hoppe[18] determined that 20^{Δ} prism was the optimum initial prism power for visual field enhancement; they found that 30^{Δ} prism was often rejected, and anything less than 20^{Δ} did not produce enough object displacement. In addition, the prisms were only placed base-out temporally and not base-in nasally on the lenses in order to avoid possible interference from the nose. The first patient, who had binocular vision, experienced diplopic images whenever he scanned into one of the prisms. The patient was trained to differentiate between the images: the blurry, virtual image produced by the prism denoted the more peripheral objects, while the clear, real image denoted the less peripheral or more central objects. The second patient, who was monocular, did not experience diplopic images, making it easier for him to adapt to the prisms. When possible, the mobility instructor should be consulted in order to incorporate the prisms into the O&M training. Over time, the prism can be moved further temporally and may even be removed altogether once the patients develop adequate compensatory scanning skills.

In order for patients to benefit clinically from sector Fresnel prism therapy, they must have a severe amount of peripheral field loss. There is no set cut-off point for this type of therapy. A prospective interventional case series by Somani et al.[19] showed that all of the patients with less than 10º of central visual field reported an improvement in all visually-related activities of daily living using spectacle mounted 20^{Δ} Fresnel prisms fitted nasally, inferiorly, and temporally around the visual axis. The most significant improvement occurred with peripheral-related tasks such as navigating around and locating targets with their side vision. Though this study showed that those with 10º of remaining visual field seemed to benefit from sector prism, we attempted prism therapy with our patients with at least 20º of visual field because they were experiencing clinically severe mobility problems. Thus, additional intervention to supplement O&M was deemed necessary.

There are also other considerations when introducing prism therapy for overall field constriction. Prism therapy may not be successful with patients who have impaired cognition because they may not understand the concept of image relocation. Secondly, patients who have poor balance from a neurological or physical condition may not be good candidates because the prisms may cause dizziness and disorientation, especially during the initial adaption period. In addition, patients who already have well-developed adaptive scanning and head turning skills tend to reject the prism.[13] Patients who also acknowledge and present with mobility complaints tend to respond better to prism. Both patients were good candidates for prism therapy because of their healthy physical and mental states and acknowledgement of their mobility trouble.

Other visual field awareness techniques were also considered. A minification strategy using a reverse telescope was rejected by the second patient and was not attempted with the first patient. This technique has the limitation of degradation of the remaining central vision. In contrast, sector Fresnel prism is a dynamic technique and does not degrade central vision because the patient is not viewing through the prism in primary gaze. Fresnel prisms are a quick and non-permanent way to assess whether this form of therapy would benefit these patients because it is relatively inexpensive, easy to apply, and lightweight. Because of its overall patient acceptance and success after months of use, the patients discussed here could be offered permanent specialty lenses with prisms in the future.

After months of use, both patients were satisfied with the prism therapy. The first patient eventually wanted to start using the sector prisms outdoors after using them indoors for over a year. The second patient also retained use of the prism. Similarly, a small-scale survey by Hoppe and Perlin[18] showed that twenty-two patients with varied amounts of field loss reported a high Fresnel prism retention rate (86.3%) and an overall high satisfaction level (average 3.63 out of 4). In particular, the study had a total of nine patients with remaining central fields of 5-10º who reported an above average mean satisfaction score of 3.69 and had an 89% retention rate, whereas the four patients with remaining central fields of 16-20º reported a lower than average mean score of 3.30 but had a 100% prism retention rate. Largely, sector Fresnel prisms help to improve awareness of peripheral objects and subsequently improve navigational ability.

Conclusion

Severe peripheral field loss causes significant disability by limiting activities of daily living. Both patients were severely debilitated by their limited peripheral visual fields. Many methods of visual field enhancement have been studied and proposed, but utilizing sector Fresnel prism remains one of the most clinically successful methods to obtain information from the missing field. The prism reduces the degree of eye movement needed to scan the environment without decreasing central acuity. Sector Fresnel prisms were successful in increasing awareness of peripheral objects, improving navigational ability, and subsequently improving quality of life for both patients discussed in this report. Although literature has suggested that those with 10º or less of remaining visual field would benefit from this form of prism therapy, our case studies showed that it could benefit patients with 20º of remaining visual field who are having debilitating mobility problems.

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a) Specialty Prism Spectacles
Chadwick Optical
1763 Old River Road
White River Junction,
Vermont 05001
802-295-5933
www.chadwickoptical.com

b) ETDRS Charts
Precision Vision
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815-223-2022
www.precision-vision.com

c) The Mars Letter Contrast Sensitivity Test
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d) Low Vision Distance Test Chart
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