Article ▸ # Using Vision Therapy to Maximize Visual Efficiency for Low Vision Patients with Central Scotoma

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ABSTRACT

Background: Patients with central scotoma report difficulty with reading and many other activities of daily living. While some patients easily adopt an eccentric viewing posture, the majority of patients need to be taught both that the scotoma exists and the most effective way to view around it. Patients with strabismus and amblyopia who eccentrically fixate are taught to view with the macula through vision therapy. Patients with central scotoma can use many of these same techniques to learn to view with an eccentric point, to develop efficient eye movements, and to develop eye-hand coordination using this new eccentric location.

Case Reports: Two cases are presented of patients with functional difficulties related to central scotoma. The first case involves a 66-year-old female with dry age-related macular degeneration. The second case is a 38-year-old female with Stargardt's disease.

Discussion: Limitations of the peripheral vision system in terms of resolution, reduced visual span, oculomotor deficits, and slower processing all contribute to difficulties with reading and slower reading speed in patients with central scotoma. Vision therapy for oculomotor skills resulted in both patients having a modest increase in reading speed, which is consistent with the current literature. Eye care providers should consider adding optometric vision therapy techniques to other methods in place in order to help patients with central scotoma maximize their visual function.

Keywords: central scotoma, vision therapy, reading eye movements, low vision rehabilitation, macular degeneration, Stargardt's disease

Introduction

Patients with central scotoma report difficulty with reading and many other activities of daily living (ADLs).[1-3] Central scotoma results in reduced visual acuity and contrast sensitivity and frequently limits the usable field of view.[4] Reduced central visual function necessitates the use of eccentric viewing to put both objects and words onto intact peripheral retina.[2] Using eccentric retina decreases reading rate because peripheral retina is not as efficient in recognizing words as the fovea, even when print size has been enlarged to compensate for reduced resolution at that eccentric retinal point.[2-5]

Magnification is often prescribed to compensate for central visual impairment by enlarging the print, but this only partially addresses the patient's functional difficulties. Even with an optimal low vision device, patients with central scotoma often still read slowly[1] and have reading difficulties that are due to factors such as impaired oculomotor control,[1-3] poor fixation stability,[1-2] reduction of visual span,[1-3] and slower temporal processing.[1]

While some patients easily adopt an eccentric viewing posture, the majority need to be taught that the scotoma exists and the most effective way to view around it.[6] One way for

the examiner to assess whether a scotoma is present is to observe the patient during distance visual acuity testing to see whether the patient consistently misses a number or letter at the beginning, middle, or end of an acuity line. Another assessment option is to have the patient view the examiner's nose at about arm's length away and ask if any facial features disappear. Sample questions include: "if you look at my nose, does it disappear," "if you look at my nose, can you tell what color my eyes are," and "if you look at my nose, can you see my eyes/forehead/chin, or does anything disappear?" To teach the patient about scotoma awareness, the examiner can explain to the patient why the number, letter, or facial feature is difficult to see or disappears from view.

Table 1: Selected Pre- and Post-Training Data

	Case 1—Patient A		Case 2—Patient B	
	Pre	Post	Pre	Post
Symptoms	Significant	Subjective Improvement	Significant	Subjective Improvement
DEM	V: 40.6 sec H: 48.4 sec E: 0 R: 1.19	V: 35 sec H: 41 sec E: 0 R: 1.17	V: 35 sec H: 61.7 sec (adj) E: 10 (O) R: 1.76	V: 32 sec H: 48 sec (adj) E: 5 (O) R: 1.46
Gray Oral	105 wpm	120 wpm	70 wpm	88 wpm

To determine the best direction for eccentric viewing, one method[6] is to have the patient view a single number on an uncluttered wall at a comfortable distance and to move his or her eyes slowly to different positions of gaze to find the position that makes the number easiest to see. This author uses a modification of this technique, holding a single number from the Designs for Vision chart (such as the 225-foot letter, which is a single number 8) at 5 feet from the patient. The patient is first asked to look directly at the number and to describe whether any part of the number is missing. Next, the patient is guided to view the target as if there is a clock dial superimposed around it, and the patient is asked whether the central target becomes clearer when viewing in different positions such as above (12 o'clock position), to the right (3 o'clock position), to the left (9 o'clock position), or below (6 o'clock position).

The literature discusses three training methods available to help patients with central scotoma to read more efficiently: eccentric viewing training (also can be referred to as preferred retinal locus (PRL) training), eye movement training, and perceptual learning.[2,6] There have been reports demonstrating the success of perceptual learning in patients with age-related macular degeneration (AMD)[1,6,7] and juvenile macular dystrophy.[2]

Patients with strabismus and amblyopia who eccentrically fixate are taught, with vision therapy, to view with the macula. Patients with central scotoma can use many of these same techniques to learn to view with an eccentric point, to develop efficient eye movements, and to develop eye-hand coordination for the new eccentric location.[8]

The following case reports describe how oculomotor vision therapy techniques were adapted to help a patient with AMD and a patient with Stargardt's disease improve their reading eye movements and develop more efficient eccentric viewing. These cases are atypical, as the need for eccentric viewing training may not be immediately apparent.

Case Report 1

Patient A, a 66-year-old white female with AMD, was seen for a low vision evaluation with the chief complaint of loss of place when reading and difficulty with reading comprehension. She also had difficulty with fine motor tasks such as putting a key in a lock and pouring liquids. Her distance visual acuity, measured with the ETDRS[a] chart, was 2/8M with the right eye using eccentric viewing and 2/6.3M with the left eye foveally. Her near visual acuity with a +3.00 add, measured with the Lighthouse "GAME" card,

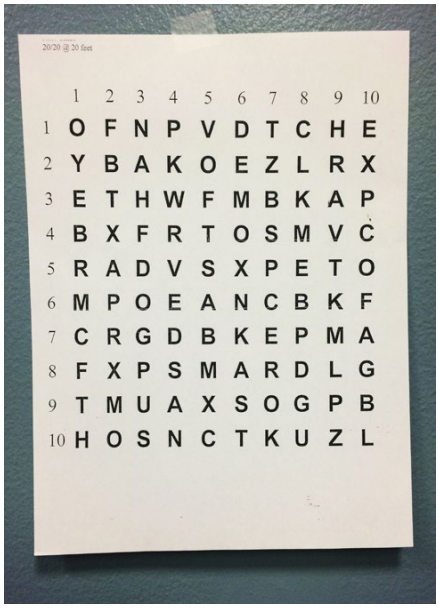


Figure 1. *Hart chart.*

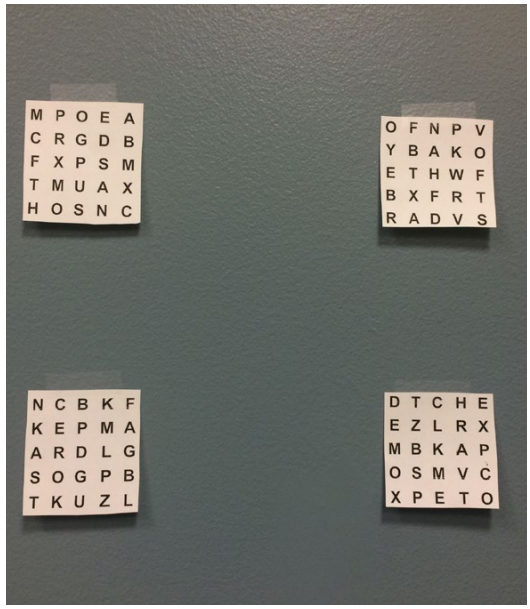


Figure 2. *Set up for four-corner Hart chart saccades.*

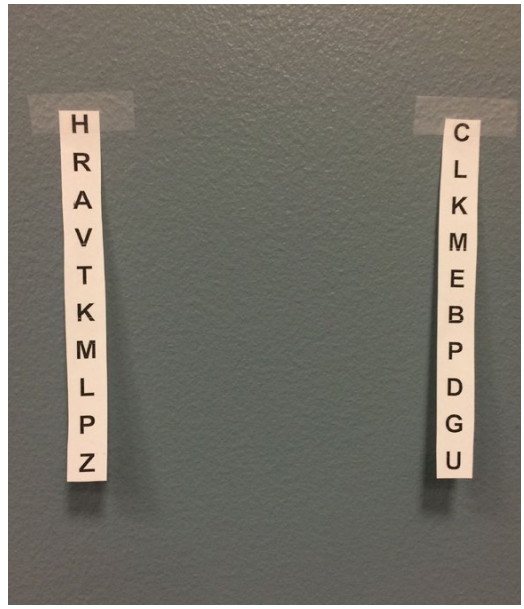
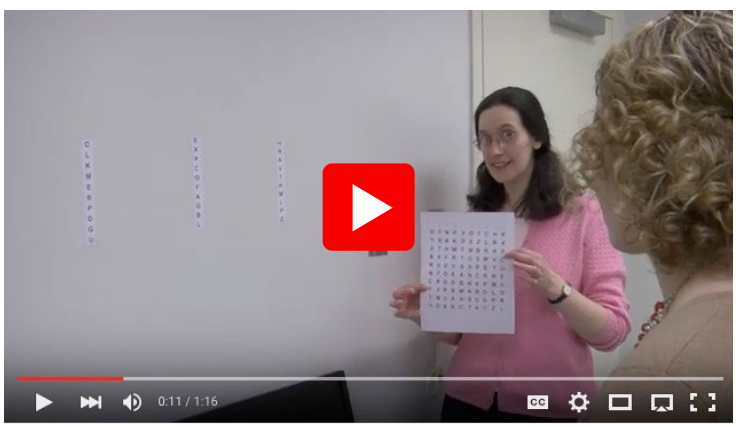


Figure 3. *Set-up for four-corner Hart chart saccades using vertical strips.*

was 1M at 33cm in the right eye using eccentric viewing, 0.5M at 33cm in the left eye, and 0.5M at 33cm with both eyes. Central scotoma size, measured with Amsler grid, was a 10-degree central scotoma in the right eye and a 5-degree paracentral scotoma to the right of fixation in the left eye. In addition to low vision aids, vision therapy was recommended with the therapy goals of improving saccades at distance and near while reinforcing an efficient eccentric viewing position and improving eye-hand coordination.

As part of her evaluation, the Developmental Eye Movement (DEM) test[b] was performed. Results are in Table 1. It was noted that during Test C, the patient slowed down in the middle of the test. Additionally, she would lose either the last one or two numbers of a line on several lines of the test. She was also given Gray oral reading passages[c] to read aloud to assess reading speed. According to Legge et al.,[9] reading speed for subjects who were not visually impaired had an average rate of 215 words per minute. Only 30% of low vision patients tested had faster reading rates than 133 words per minute, which is two standard deviations below the mean. This patient's reading speed was 105 words per minute, which is more than two standard deviations below the mean. As she read the Gray oral reading passages, she would frequently lose her place as she was reading across each line of print. These tests demonstrated that as she read across a line of print, she read into her scotoma to the right of fixation. Additionally, her right eye was the dominant eye before acquiring AMD. Despite her good central acuity with her left eye, she was experiencing rivalry between her left eye and her right eye, which had a large central scotoma. Reading was more fluent when her right eye was occluded.



Four Corner Hart Chart Saccades

Based on these results, therapy activities were conducted with the right eye patched and with the left eye using eccentric viewing. The patient was taught to view slightly above the object of regard. For sessions one through three, the focus was on improving large angle saccades at distance (6 feet) using the Hart

Figure 4. *Marsden Ball.*

Figure 5. *Sherman rotator disc, courtesy of Dr. Arnold Sherman, shown on pegboard rotator.*

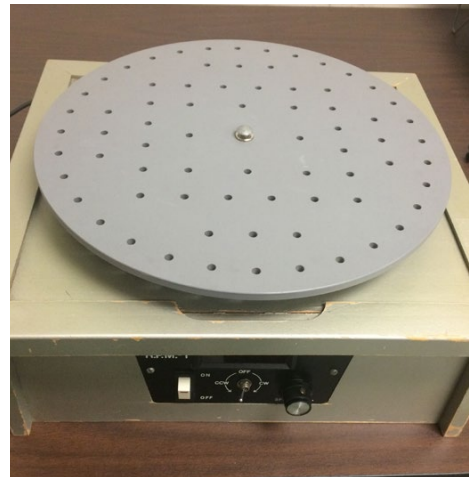
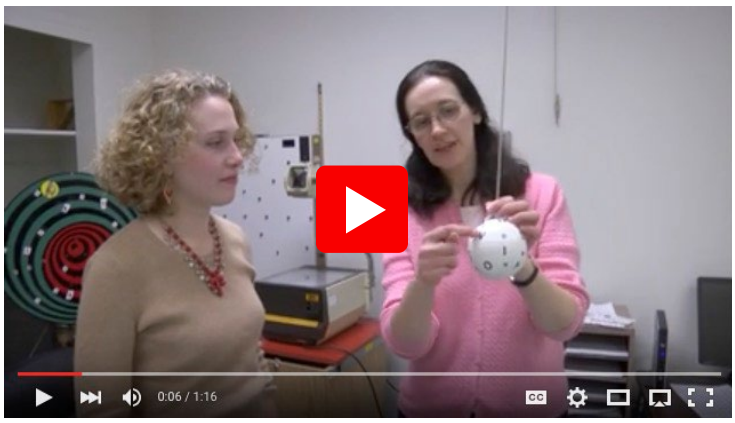


Figure 6. *Pegboard rotator.*

Hart Chart Saccades using vertical strips.



Marsden ball bunting.

chart. The Hart chart is a 10x10 grid of letters (Figure 1). In order to use this chart to work on large-angle saccades, the chart was cut into four corners (four square pieces), each of which was a 5x5 grid (Figure 2). One exercise used was to place the corners on the wall, separated by 12 inches both horizontally and vertically. The patient would read the first line in each square piece, then the second line in each square piece, and so on until all lines were read aloud. Once this exercise was completed with good speed and accuracy, the chart was used differently. The next exercise was to cut the Hart chart into vertical columns. The exercise began with two columns separated by 12 inches (Figure 3). The patient would read the letters in each row going across from right to left. Once the exercise was completed with good speed and accuracy, additional rows were added until the full 10x10 grid was able to be used.

Near saccadic work included tracking with letters, numbers, and words. One exercise used was to locate and to circle, for example, all the times the letter "e" appeared in a paragraph of nonsense words. Another exercise was to find all the times the number 2 appeared in a line of random numbers. The materials used were in 12pt font. This size font was chosen to emphasize the quality of saccadic work over acuity since the patient was already able to see standard print without difficulty.

Eye-hand coordination work included Marsden ball bunting, Sherman rotator disc, and pegboard rotator with tactile reinforcement. The Marsden ball (Figure 4) had large letters that were 12mm in size and small letters that were 6mm. The ball was hung at a height slightly below eye level. The patient held a bunting stick with a colored mark in the center and tapped the large letters with the colored mark, calling out the letters as she tapped them. As with the tracking exercises done at near, emphasis was

Sherman rotator with tactile reinforcement.

placed on accuracy of the saccades and eye-hand coordination rather than identification of small letters. The Sherman rotator disc (Figure 5) is similar to the letter and number training disc.[b] The disc used had large letters that were 12mm and small letters that were 6mm and was placed on a pegboard rotator. The rotator was set to move at a slow speed of 4 rpm. The patient stood about one foot in front of the rotator and located a letter called out by the examiner, pointed at it with a bunting stick, and followed it for one or two rotations. This was then continued with additional letters. As this exercise was completed with good accuracy, she was moved further back to two and three feet and given a longer bunting stick. The pegboard rotator (Figure 6) was used by having the patient select a peg, hover over a hole in the pegboard, and as the rotator moved at a speed of 4 rpm, she would follow the hole for one to two rotations and then insert the peg. When the activities using the rotator were completed with good accuracy at 4 rpm, speed was increased to 6 rpm and then 8 rpm.

In therapy sessions four through six, distance saccadic work moved to a higher level as the full Hart chart was used to work on small-angle saccades, and Hart chart coding was added. Hart chart coding involves placing the Hart chart at a distance of 6 to 8 feet, and a page with a code of coordinates is placed in front of the patient. An example of coordinates would be "9-3," meaning to move 9 letters down and three across. The patient would write in the corresponding letter on the Hart chart in this position, which in this example is "s." The patient continued filling in the code until a phrase was generated. At near, previous activities were continued, and both CPT[d] and paper/pencil visual search and visual scan were added, as well as CPT visual coding. CPT visual search involves finding a target stimulus (for example, a set of three numbers or set of three letters) in a field of similar stimuli that are arranged in columns. A sample set up would be to have 3 columns of 15 rows each. The patient is asked to find a target, for example "186," and the target is hidden among other combinations of those three digits (such as 681, 861, etc.). The patient makes saccades between the columns. CPT visual scan is different because the patient finds stimuli of one type, such as numbers, in a field of stimuli of a second type, such as letters. A sample set up would be to find 10 numbers in a field of 100 letters. The patient makes saccades along each line. CPT visual coding asks the patient to fill in blank spaces to solve the code using a key at the top of the screen. The patient makes saccades back and forth from the key to the code. The program can be set up to use symbols for the key and numbers for the code or another combination. To work on perceptual span, CPT tachistoscope was added. The patient began with the program set to flash three numbers for one second. She needed to remember the numbers and type them in when they disappeared. As speed and accuracy improved, the time that the numbers flashed was decreased, and the number of digits was increased to four and then five numbers. Eye-hand coordination activities were expanded to include dotting Os and stringing beads. The dotting Os activity was begun with larger letter Os, encouraging the patient to place a dot directly in the center of the letter. As this task got easier, the Os were slowly decreased in size. The bead stringing activity was begun with thin string and beads with larger openings. As this task got easier, smaller beads with smaller openings were used.

In therapy sessions seven through nine, all previously stated activities continued, but a timing component was added to the saccade work, and the VisionBuilder[e] moving window guided reading program was also incorporated.

Case Report 2

Patient B, a 37-year-old black female with Stargardt's disease, was seen for a low vision evaluation with the chief complaint of difficulty reading small print even with her current low vision device. Her distance visual acuity, measured with the ETDRS chart, was 2/12M with the right eye using eccentric viewing and 2/12M with the left eye using eccentric viewing. Her near visual acuity, measured with the Lighthouse "GAME" card, was 1.6M at 20cm in the right eye, 1.6M at 20cm in the left eye, and 1.25M at 15cm with both eyes. Central scotoma size, measured with Amsler grid, was a 10-degree central scotoma in the right eye and a 10-degree central scotoma in the left eye. In addition to low vision aids, vision therapy was recommended with the therapy goals of improving saccades at distance and near while reinforcing efficient eccentric viewing position and improving eye-hand coordination.

As part of her evaluation, the Developmental Eye Movement (DEM) test was performed. Results are in Table 1. It was noted that during Test C, the patient read all of the numbers slowly, and additionally, she would miss numbers either in the middle or at the end of the line on most lines. She was also given Gray oral reading passages to read aloud to assess reading speed. The patient's reading speed was 88 words per minute, which is more than two standard deviations below the mean.

Therapy activities during sessions one through three were conducted binocularly and using eccentric viewing. At distance, the focus was on improving large angle saccades at distance (6 feet) using an enlarged Hart chart (1.5x) cut into four corners and then columns, as described in Case Report 1. No distance device was used during these initial sessions since the plan was to improve eye movements alone before introducing spotting activities with the telescope, which would help her to use her telescope more efficiently. The patient had difficulty with the 4-corner exercise due to crowding. The corners were used with the patient reading the first and last letter in each square, and when this was completed with good speed and accuracy, columns were utilized. The columns were begun further apart, at 16 inches. She was very compliant with home activities and would bring the columns closer together every three to four days. Near saccade work included tracking with letters, numbers, and words. The word tracking exercises were based on sample activities described by Freeman.[8] He suggests beginning with 16pt font and two-letter words and slowly increasing the length of the words up to five letters, while decreasing font size to 12pt font as the patient improves. A 16D handheld magnifier with LED light was used, allowing her to see 0.6M at 10cm. As with the patient in Case Report 1, the focus was on improving quality of saccades over seeing small print. Mazes were also used to work on tracking, motor planning, and eye-hand coordination. At first, this patient experienced difficulty with planning and strategy, but this improved with time. Additional eye-hand coordination work included Sherman rotator disc and pegboard rotator with tactile reinforcement as described in Case Report 1.

In therapy sessions four through six, distance saccadic work moved to a higher level as the full Hart chart was used and Hart chart coding was added. In addition to Hart chart coding as described in Case Report 1, a small pegboard was placed in front of the patient, and she would place a peg to mark each corresponding place where the letter E appeared, then remove the pegs and repeat with other frequently appearing letters such as A and O. The Sherman rotator disc was used for saccade work as well. She sat two feet from

the rotator and identified the large letters in each of eight sections as the rotator moved at a speed of 4 rpm. As she improved, the speed was increased up to 6 rpm. In session five, she began using her 4x12 monocular handheld telescope for distance saccade work. At this point, she was able to use the Hart chart as four corners and read the squares line by line using her telescope. At near, previous activities were continued. To work on perceptual span, CPT tachistoscope was added. This activity was begun using three numbers flashing for 1.5 seconds because she had less than 70% accuracy with one second. As she improved, time was reduced, and digits were increased to four and then five numbers. Eye-hand coordination activities were expanded to include direct copy of DLM pegboard design cards[f] onto a small pegboard placed in front of the patient. As this task was completed with good speed and accuracy, the activity was made more difficult by asking the patient to copy the picture as it would look if turned 90 degrees or 180 degrees.

In therapy sessions seven through nine, all previously stated activities continued, but a timing component was added to the saccade work, and the VisionBuilder moving window guided reading program was incorporated into the therapy regimen.

Discussion

Difficulty with reading is often the main reason that patients seek low vision rehabilitative care.[1-3,6,10] Patients with central scotoma have more difficulty with reading than patients who have reduced central acuity but who do not have central visual field defects.[11]

Those with central scotoma not only have to adapt to reading with the aid of a low vision device but also have to learn to read efficiently using a new eccentric retinal point. An eccentric point in the peripheral retina is not as quick as the fovea at identifying or processing words.[5,12] Visual acuity, as well as the visual span, or number of letters that can be taken in and processed in a given fixation,[1,6,12] is reduced in the periphery. This results in slower reading speed for patients with central scotoma as compared to those able to read with the fovea.[1,3,6,8]

Slower reading is attributed to a combination of factors, which include sensory deficits, eye movement deficits, and processing deficits of the peripheral visual system.[7,13] When either text is manipulated or optimal magnification aids are given in order to compensate for reduced visual acuity and reduced contrast, reading speed does not return to normal.[1,2,7] Reduced visual span[1-3] and associated slowed temporal processing[1] are a major cause of reduced reading speed, as is impaired oculomotor control, including inaccurate saccades, increased number of saccades, poor fixation stability, increased duration of fixations, and use of eccentric viewing.[1-3,7,12,13]

After nine sessions of vision therapy, with the goal of improving reading eye movements while reinforcing efficient eccentric viewing and improving eye-hand coordination, both patients reported subjective improvement in symptoms. The first patient reported increased comfort with reading and had developed compensatory mechanisms for fine motor tasks. The second patient reported subjective improvement with reading and spotting. For both patients, objective improvements in reading speed were revealed post-therapy (Table 1). These results are consistent with the literature, which suggests that perceptual learning for eye movement control and visual span can increase reading speed in patients with AMD and juvenile macular dystrophy.[1,2,6,7]

The oculomotor system can be trained. With training, fixation and saccades can become more stable and accurate. Training can also reinforce the use of an appropriate eccentric point and can make reading more efficient using that eccentric point.[11,12] The observed increases in reading speed with the patients

discussed were modest (Patient 1 had an increase of 15wpm; the increase was 18wpm for Patient 2), which is also consistent with the literature. Nguyen et al.[2] reported an increase of 20 words per minute, while Seiple et al.[6] reported an increase of 35.5 words per minute. Both authors noted that though the increases were modest, the patients benefitted, and this can result in an increase in quality of life.

A motivated low vision patient will be more likely to achieve success through vision therapy. The process of learning to read using a new eccentric retinal point can be frustrating to the patient and is a time-consuming process.[8]

Weekly training was recommended for both patients, beginning with five trial sessions. Before therapy commenced, each patient was educated regarding expectations and the commitment involved. In each case, after the five trial sessions, both the author and the patient felt that progress was being made, and it was recommended that training continue. Quantitative goals were not set as an indication of when to end therapy, but therapy would be considered complete when the patient demonstrated accurate and efficient reading eye movements, improvement on objective reading assessments that were at minimum in line with the literature, and subjective improvement in activities of daily living.

The second patient was able to commit to weekly training sessions and demonstrated compliance with home activities, which resulted in her seeing progress from week to week and maintenance of motivation. After 9 sessions, a progress check was performed. Therapy goals were reached, and she was satisfied with her progress, so additional therapy sessions were not recommended. In contrast, the first patient demonstrated inconsistent compliance both with attendance and home activities and therefore made slower progress in reaching her therapy goals. After 9 sessions, a progress check was performed. Objective improvement was demonstrated. The patient noted subjective improvement but felt that there had not been enough improvement in her reading speed. Additional therapy sessions were recommended, but she chose not to pursue this recommendation.

Training for reading eye movements, as well as for eccentric viewing, is also performed by occupational therapists[14] and certified low vision therapists.[15] The training performed by these therapists has similar goals to those presented in the above case reports, but the approach to therapy and techniques used will vary depending on the training of each professional. A detailed description of the clinical approach and training techniques utilized by these professions is beyond the scope of this paper.

Conclusion

These case reports represent two patients where modest increases in reading speed were achieved after utilizing optometric vision therapy techniques, which are typically used to train oculomotor skills, strabismus, and amblyopia. These techniques were modified to enhance pursuits and saccades, as well as to enforce efficient eccentric viewing posture The need for vision therapy in each case may not be immediately obvious, but both patients were experiencing functional difficulty at distance and near, and both objective and subjective improvement were noted following vision therapy. Eye care providers should consider adding these methods to other methods in place to help patients with central scotoma to maximize their visual function. More research is needed in the use of vision therapy techniques with low vision patients.

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