Article ▸ Visual Field Defects Secondary to a Cerebrovascular Accident

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ABSTRACT

Background: Visual field defects occur frequently with acquired brain injury (ABI). Complex visual-motor and sensory-motor processes are affected in visual field defects, often resulting in significant impact to overall function, demeanor, and quality of life. Neuro-optometric rehabilitation, which may include lenses, visual rehabilitation therapy, and referrals to other professionals, can result in improvement in overall function, demeanor, and quality of life for individuals suffering from visual field defects secondary to ABI.

Case Summary: A 74-year-old Caucasian female presented 1 month following a cerebrovascular accident of the right side with concern about left visual field loss. Symptomatology included that her "eyes do not seem to focus together," blurry vision especially in left field, re-reading lines or words while reading, poor depth perception, loss of balance, disorientation, and difficulty with peripheral vision. The evaluation revealed the diagnosis of a superior left field quadrantanopia OD, left hemianopia OS, intermittent alternating exotropia of convergence insufficiency type, and oculomotor deficits of saccades and pursuits. Neuro-optometric rehabilitation, consisting of an active vision rehabilitative therapy program of in-office sessions and prescribed home activities, was prescribed. The vision rehabilitative therapy program encompassed compensatory oculomotor scanning, sensory-motor integration, and development of deficient binocular and oculomotor skills. In addition, the program also included the development of improved visual processing skills in the areas of visual spatial relations, visual memory, and processing speed (including span and tachistoscopic recognition). The outcome of this case yielded successful overall achievement of the patient's and doctor's goals, as well as significantly improved symptomatology and enhanced quality of life.

Conclusion: Appropriately prescribed neuro-optometric rehabilitation yields successful outcomes on quality of life post ABI with visual field defects. Diagnostic scrutiny of visual field defect-related conditions, such as visual midline shift, unilateral spatial inattention (USI), and focal-ambient integrative processing dysfunction, is important to optimize treatment plans. In addition, consoled phasic induction of applicable prismatic lenses maximizes prism acceptance and improves the outcome of neuro-optometric rehabilitation.

Keywords: acquired brain injury, cerebrovascular accident, focal and ambient processing, hemianopia, neuro-optometric rehabilitation, unilateral spatial inattention, visual field defect, visual midline shift

Background

Visual field defects of various types and degrees of impairment are common among individuals affected by an acquired brain injury (ABI) and have significant impact on recovery and overall function. Visual field defects affect the visual processes involved in sensory-motor relations to organize and gain meaning of visual space and to administer related executive functions. For instance, small scotomas near central fixation can disrupt tasks requiring fine visual discrimination, such as reading.[1] In individuals with an ABI, the disruption in the previously intact system leads to a series of visual processing disruptions and resulting dysfunction.

The visual field defect homonymous hemianopia, which is loss of vision to the same side of half of each eye's visual field, occurs in approximately 10% of stroke patients.[2] Homonymous visual field defects are among the most frequent disorders that occur in the elderly after vascular brain damage and can have a major impact on quality of life.[3] Homonymous hemianopias are commonly associated with an egocentric visual midline shift (perceived straight-ahead is usually in the direction opposite to the affected visual field), resulting in veering to one side and running into or tripping over objects in the affected field during ambulation.[1]

Visual field defects following an ABI can be associated with unilateral spatial inattention (USI), which is a lack of awareness and attentional control on the contralesional side of space in which individuals are unresponsive to events, objects, and people in the related side of external space.[4] USI patients may even fail to acknowledge contralesional parts of their own body or of mental representations.[5] The acute onset of these visual disruptions of external space caused by the visual field defect can be debilitating to both overall function and demeanor. Past experiences developed from intact sensory-motor systems have minimal value to the visual system with new visual field defects.[6] Frustration and difficulty dealing with inadequacies and loss of independence typically result, in addition to apprehensions about safety. USI has a significant impact on the overall outcome following brain damage.[7]

Neuro-optometric rehabilitation, which includes lenses, visual rehabilitation therapy, and referrals to other professionals, can result in improvement in overall function, demeanor, and quality of life for individuals suffering from visual field defects

secondary to ABI. Studies have shown that individuals with visual field deficits who are active in vision rehabilitation show the best prognosis for achieving their personal goals of safety and independence.[1] For instance, a study showing that stroke patients with persisting visual field defects possessed significantly reduced mental health compared to that of stroke patients without visual field defects.[2] This study concluded that individuals with persistent visual field defects should be offered additional neuropsychological rehabilitation that may improve visual functioning or supportive psychotherapeutic interventions.[2] Furthermore, a high incidence of patients with USI following stroke are misdiagnosed as having dementia.[8] Many patients with a cerebrovascular attack (CVA) have undiagnosed USI, which puts them at risk for injury.[9]

The present case of a visual field defect secondary to CVA emphasizes the importance of diagnostic scrutiny of visual field defects and their effect on sensory-motor function following an ABI. The case also highlights the significance of consoled phasic induction of applicable prismatic lenses to maximize prism acceptance and to improve the neuro-optometric rehabilitative outcomes.

Course of this Disorder

CVA is a leading cause of death in the United States, killing nearly 130,000 individuals each year.[10] CVA is more common in the elderly, although it can occur at any age.[11] CVA, otherwise known as stroke, occurs when there is an interruption in blood flow that disrupts oxygen to the brain cells.[12] Eighty-five percent of strokes are ischemic, in which an artery in the brain becomes blocked.[13] The other two common types of stroke are hemorrhagic and transient ischemic attack.[13] Eighty percent of all strokes are preventable, which begins with management of risk factors, including high blood pressure, cigarette smoking, atrial fibrillation, and physical inactivity.[14] The most important risk factor to control is hypertension, which is the cause of more than half of all strokes.[14]

A CVA can be debilitating to one's overall function and can negatively affect cognitive functions such as memory, attention, perception, and planning.[15] Visual impairments contribute to these deficits and are common after a CVA. A recent study showed that of 915 patients following a CVA, 54% were diagnosed with ocular motility abnormalities.[16] These were isolated impairments in 50% of cases and were associated with other ocular abnormalities in the other 50%, including impaired convergence, nystagmus, and lid or pupil abnormalities.[16] Furthermore, 35% of the patients experienced symptoms of diplopia and blurred vision.[16] Visual field loss has been reported in up to a quarter of stroke survivors.[17] Visual field loss is a loss of part of the field of vision and typically involves the peripheral field of vision with a CVA.[18] The most common type of visual field loss associated with CVA is homonymous hemianopia, which occurs in approximately two-thirds of those with visual field loss.[18] Other common types of visual field loss following a CVA is the loss of a quarter of the visual field (homonymous quadrantanopia) and an island-like area of blindness (scotoma).[17] Visual field loss following stroke has been attributed to cortical strokes, in which the visual pathway is damaged.[18] Vision care of an individual who has suffered a stroke is crucial given the high prevalence of visual deficiencies after stroke.

Table 1: Presenting Signs and Symptoms

Eyes do not seem to focus together
Dry/irritated eyes, gritty/sandy sensation
Halos around lights
Itchy eyes
Blurry vision, especially in left field
Shadowy vision
Tired/sore/uncomfortable eyes
Re-reads lines or words
Loss of place while reading
Reduced memory
Uses finger as a marker to keep place while reading
Tilts/turns head when reading and writing
Poor depth perception
Loss of balance
Disorientation
Poor sense of direction
Decreased memory/forgetfulness
Poor posture
Sensitivity to light and glare
Difficulty with peripheral vision

Case Report

History

CC, a 74-year-old white female, was referred by a hospital-based physical therapist for a consultation regarding treatment options for visual field loss. CC was retired, and prior to her insult, she enjoyed reading, sewing, line-dancing, and cooking. She lived with her husband in a private home with moderate independence, with the exception of her husband performing all of the driving. CC's main reason for the consultation was to determine the probability of gaining function in her left visual field and partaking in her pastime activities with greater ease and enjoyment.

CC experienced a stroke on her right side. She was hospitalized for 3 days and was released with instruction to enter rehabilitation. She was also advised to lower her dietary fat and salt intake and was referred to her cardiologist and general physician for routine care. CC was prescribed Tylenol and Plavix-potassium. CC recalled no double vision immediately following the insult. She reported complete loss of her left field with some recovery and consistent blur of her left field of vision.

Table 1 shows CC's presenting visually related signs and symptoms. Her major concern was the effect of her reduced left visual field on her activities of daily living. She reported

Table 2: Diagnostic Data from Initial Assessment

REFRACTIVE STATUS
Unaided Distance Visual Acuity:
OD 20/50 full Snellen chart, OS 20/25 full Snellen chart (slow and laborious)
Corrected Near Acuity (cc habitual readers +2.50 OU):
OD reduced Snellen (RS) 80 full Snellen chart, OS RS 30 full Snellen chart (slow and laborious)
Autorefraction: OD +1.00-1.75x055, OS +0.25-0.50x132
Retinoscopy: OD +1.25-1.75x055, OS +0.25-0.50x130
Subjective Refraction:
OD +1.25-1.75x060 Distance Visual Acuity: 20/20 Near Visual Acuity: RS 20 Add: +2.50
OS +0.50-0.50x135 Distance Visual Acuity: $20/30^{+2}$ pinhole no improvement Near Visual Acuity: RS 30 Add: +2.50
Keratometry: OD 45.50 x 44.50 @ 051, OS 44.75 x 42.00 @ 007

BINOCULAR VISION
Cover Testing: Distance: no movement/ortho Near: intermittent alternating exotropia, 90%, >OS, 12-14 prism diopters/6 exophoria
Near Point of Convergence: 7/8 inches OS out, no diplopia reported
Comitancy Testing, Near Cover Testing 9 fields: Unilateral: intermittent alternating exotropia, 90%, >OS, 12-14 prism diopters; Alternate: 6 exophoria
Motor Fusion:
Von Graefe Phoria Distance and Near: constant OS suppression
Positive and Negative Vergence Ranges Distance and Near: constant OS suppression
Vergence Facility: suspect possible constant OS suppression
Sensory Fusion:
Worth 4 Dot: flat fusion at distance, intermediate, and near (pulled head away at 5 inches-repeatable) ranges with no movement on unilateral cover test
Stereo Acuity Testing: appreciation of 1 out of 4 on 500 seconds of arc Randot stereo, 40 seconds of arc on Wirt circles

OCULOMOTOR
Gross Pursuits Monocular and Binocular: full and smooth with 1+ head movement
Gross Saccades Monocular and Binocular: 90% gross undershoots, 1+ head movement
Visagraph Testing: Increased number of fixations, regressions, and duration of fixation; decreased span of recognition, words per minute, and comprehension OD, OS
Developmental Eye Movement (DEM) Test: Horizontal 28th percentile, Error >60th percentile (based on ceiling age of 13.11 years)

LENS/PRISM TRIALS
Trialed subjective refraction for distance and near, CC preferred her habitual readers at this time.
Trialed base-in prism in 2-6 prism diopter ranges, CC felt discomfort with prism in place.
Trialed yoked prisms base left in 2-15 prism diopter ranges, CC felt discomfort with prism in place.

OCULAR HEALTH
Pupils: Equal, round, reactive to light with no afferent pupillary defect
Confrontation Fields (single presentation):
OD: reduced accuracy and appreciation in inferior left and right quadrants
OS: reduced accuracy and appreciation in left superior and inferior quadrants
Anterior and Posterior Segment: Unremarkable other than posterior chamber intraocular (PCIOL) lenses clear OD, OS and 1+ vitreous degeneration OD, OS dilated fundus examination included OD, OS
Noncontact Tonometry: 15 mm Hg OD, 14 mm Hg OS
24-2 supra-threshold visual field test (1 gtt Proparacaine 0.5%, 1 gtt Tropicamide 1% OU): Absolute superior left field quadrantanopia defect OD and left superior and inferior temporal hemianopia OS (showing absolute defect in superior quadrant and dense defect inferior)
Humphry visual field 30-2 test (from exam with ophthalmologist): Absolute superior left field quadrantanopia defect OD and left superior and inferior temporal hemianopia OS (showing absolute defect in superior quadrant and dense defect inferior; Figure 1)
USI Testing:
Clock Test: 100% completion, filled in clock counter-clockwise
Line Bisection Cross Out Test: CC bisected all lines in the middle section. Note: CC completed upper-right quadrant first, lower-right quadrant second, lower-left quadrant third, and upper-left quadrant last.

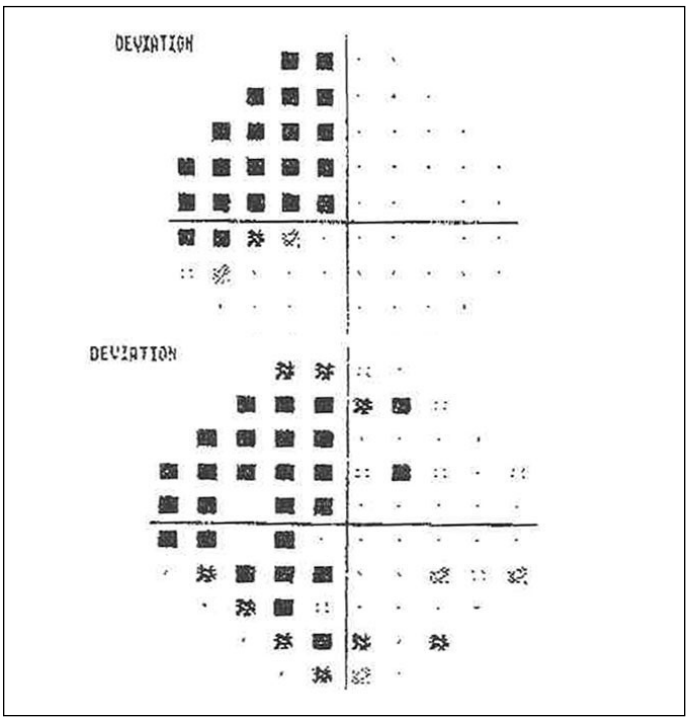

Figure 1. *Pre-therapy visual field (top OD, bottom OS)*

that she no longer enjoyed reading, could not drive, and was constantly frustrated because she did not see things that her husband informed her were right in front of her. Furthermore, she reported that she was often startled as her husband would appear immediately before her and she could not see him approaching. She noted that since the insult, her activities of daily living mostly entailed sleeping, eating, and visiting with neighbors. She was on the computer 1 hour per day and read about 1-2 hours per day. CC also expressed a strong desire to line dance again, especially to turn without losing her balance and feeling disoriented. She also desired to improve her memory.

CC's medical history was positive for fatigue, headaches, heart disease, an allergy to penicillin, hypertension, elevated cholesterol, and arthritis. Her surgical history was positive for a hysterectomy, gall bladder removal, and hernia repair. Her daily medications included the following: Atacand, Coreg, Hydrochlorothiazide, Plavix, Tums Ultra, Lipitor, Zocor, Vitamin D3, multi-vitamins with minerals, Lotrisone topical cream, and Elocon 0.1% topical cream. Her family history was positive for heart disease, cancer, and macular degeneration. CC's eye health history was positive for cataract removal with Phaco-Restor-Aspheric lens implant (+22.50) of both eyes and selective laser trabeculoplasty in both eyes. Her ocular daily medications included Optive in both eyes as needed. She wore over-the-counter reading glasses.

CC received a few hours of occupational and physical rehabilitation immediately following her hospital release post-insult. She walked without aid with mildly decreased gait, and her dexterity and coordination appeared intact. Her posture appeared well-balanced and aligned both sitting and walking. Her cognitive function appeared intact, with adequate recall, conversation skills, and illustration of wit. Her receptive and expressive language and speech pronunciation also appeared to be within normal ranges. Energy level, responsiveness, mood, and social interactions all appeared within normal levels. CC independently performed and maintained proper hygiene and physical appearance. She cooked and performed household chores independently, and she refrained from driving.

Existing Condition Background

Vessel occlusion causes approximately 80% of strokes; the rest are hemorrhagic.[9] The specifics of CC's cerebrovascular accident (CVA) are unknown; however, based on her medical history review, she was at risk secondary to her hypertension and high cholesterol. She was currently monitored routinely by her cardiologist and general practitioner, and she reported compliance with her medications to regulate her blood pressure and cholesterol for prevention of reoccurrence.

Diagnosis

Table 2 illustrates the diagnostic data from CC's initial assessment. The following are her diagnoses:

1. Mild compound hyperopic astigmatism OU and presbyopia
2. Concomitant alternate intermittent exotropia of convergence type, greater OS, with suppression OS
3. Oculomotor dysfunction of pursuits and saccades
4. Superior left field quadrantanopia defect OD and left hemianopia OS

Coordination with other disciplines:

CC was released from physical therapy prior to her first assessment. I recommended that she continue to be followed by her neurologist, cardiologist, primary care physician, and ophthalmologist. Initial testing results and progress results throughout the neuro-rehabilitation treatment process were sent to all professionals involved in CC's care.

A comprehensive consultation took place after CC's initial assessment to educate CC and her husband about her conditions, the recommended treatment plan, and home/lifestyle recommendations. Specifically, CC's husband was educated about how he could best support CC's visual field defect in her personal, peri-personal, and extra-personal spaces. Specifically, with regard to CC's personal space, CC's husband was cautioned about her reduced balance and depth perception and was informed specifically to refrain from turns in their line-dancing class and to stay beside her while walking on stairs, uneven surfaces, and curbs. Likewise, in relation to peri-personal space, he was educated to assist in dissipating any inattention of CC's visual field by engaging her in joint attention to her left field, reinforcing scanning into the left field, and also being aware of her left field of vision (e.g., reminding her to finish food on the left side of

her plate, to apply make-up to the left side of her face, etc.). Lastly, in relation to extra-personal space, he was instructed to use verbal cues when entering a room or field of view from her left side. He was cautioned about safety regarding this concern (e.g., cooking together in the kitchen) and CC's anxiety about being startled by unexpected appearances in her left field.

Treatment Plan

New visual space

Goals as reported by CC included: to enjoy reading again, to increase awareness of her left field of vision, and to improve balance (specifically for the capability to perform turns in line-dancing again).

Doctor's goals included: achieving the patient's goals by eliminating/minimizing presenting signs and symptoms, increasing her left visual field awareness and function, heightening vestibular function, enhancing focal-ambient processing, improving best-corrected visual acuity at near and distance of the left eye, eliminating exotropia, enhancing stereopsis, developing accurate and efficient saccadic and pursuit abilities, and enhancing visual processing with specific focus on visual memory, visual spatial, and processing speed.

The prognosis through a neuro-optometric rehabilitation program for the above-mentioned patient and doctor goals was overall fair for the reasons outlined below.

Visual Field Influencing Factor:

Improved functionality and awareness of CC's left visual field showed adequate prognosis as CC showed a strong cognitive ability and appeared to respond favorably to scanning techniques and compensating strategies. She also showed minimal signs of USI at the initial assessment. Proposed prognosis of adaptation to spectacle prism training (i.e., Fresnel sector prism on left lens base out) was likewise deemed favorable. CC and her husband were clearly educated about the set goals and expectations with regard to the visual field defect. Prior to initiation of the treatment plan, it was concurred that the neuro-optometric rehabilitation plan would aim to improve functional vision post-insult to obtain stabilization, organization, and awareness of her peripheral vision. CC and her husband were educated that the rehabilitation program would aim to improve performance in activities of her daily living and give improvements in her presented signs/symptoms rather than actual visual field recovery. CC and her husband were informed that actual visual field recovery is modest (averaging 5-7 degrees in hemianopia),[1,8] and they were shown specifically that if any modest recovery occurred, it would take place at the gradient inferior border of the inferior left field defect.

Strabismic Influencing Factors:

It was suspected (however unknown) that the exotropia was acute-onset secondary to the neurological insult of the CVA. Exotropia and high exophoria have been found to be comorbid with ABI and associated with imbalances in focal and ambient processes.[6] Flat fusion was obtained, illustrating possible acute standing, as suppression typically ocurs over time. The exotropia was also intermittent, and suppression was only noted during phorometry (phoria and fusional measures), which may have posed a higher convergence demand and further imbalance of the focal-ambient processing. Furthermore, the favorable prognostic characteristics of her strabismus included concomitancy, small magnitude, exo direction, intermittent frequency, and normal correspondence.

Age-related Influencing Factors:

CC's age did not pose a significant prognosis risk, as she possessed high cognitive function. She lived in a private residence with her supportive husband who adequately provided transportation. It was expected that CC would have a good prognosis with vision rehabilitative therapy technique, application, and compliance.

Neuro-Optometric Rehabilitation Plan

Inter-disciplinary Approach

CC was compliant with my recommendations to continue to be followed routinely by her neurologist, primary care physician, and ophthalmologist. I also recommended that CC continue with physical and occupational therapy; however, CC insisted that she was dismissed with goals obtained in acute care.

Lenses

CC was opposed to using glasses even during vision rehabilitative therapy sessions other than her over-the-counter readers. I recommended that CC receive two single vision prescription lenses (versus progressives, which might exacerbate her disorientation), one for near and one for distance. CC was also educated that single vision lenses increase accuracy and stability for the proposed use of Fresnel prism trials. It is typical for individuals affected by an ABI to show elevated responses to subtle refractive error corrections to further support stability of the focal-ambient process change. CC also had a reasonable amount of refractive error in her right eye and showed significant visual acuity improvements in the right eye in the distance and near with the corrected prescription in place as compared to her current habitual system of unaided acuities for the distance and readers at near. CC deferred the recommended change to her habitual system. Furthermore, it was recommended that CC try a sector Fresnel prism base left on her left lens at minimum during vision rehabilitative therapy sessions in which prism lens adaptive training would be administered. During initial prism trials of small amounts of base-in prism (2-6 pd) to assist with her exophoric posture and focal-ambient processing, and during trials of full base left yoked prisms (2-15 pd) and sectoral base left prism (2-15pd) on the left eye, CC felt that the prisms were discomforting and deferred their application.

Table 3: Symptomatology and Activities of Daily Living Progression

Initial Assessment
No longer enjoys reading
Frustrated because she does not see things that her husband informs her are right in front of her
Often startled as her husband would appear immediately before her and she could not see him approaching
Strong desire to line-dance again, especially to turn without losing her balance and feeling disoriented

First Progress Evaluation (concluding 8 sessions)
Improvements in reading (rereading lines, skipping words, and using finger to keep place less)
Balance and posture improving, still experiencing some dizziness and disorientation
No noticeable improvement in peripheral vision

Progress Evaluation 2 (concluding 16 sessions)
Improvment in reading skills
Improvment in balance abilities
More stable in line-dancing but still gets dizzy when performing a turn

Progress Evaluation 3 (concluding 24 sessions)
Improved side vision, proudly demonstrated her awareness of both of her thumbs simultaneously with her arms stretched out to her sides
Enjoying reading again
All presenting signs and symptoms improved, except difficulties with finding objects that she reported were directly in front of her
Memory skills still reduced

2-month Follow-up Evaluation (completed 24 in-office sessions, moderate compliance with prescribed home maintenance program)
Improved balance, could now perform some turns when line-dancing
Visual field remained intact, no longer surprised by her husband "popping up" in her left visual field
Reading and cooking easily
Still struggled to find things (e.g., her watch sitting on her dresser or calendar which had been propped up on wall, rather than lying flat)

A

Vision Rehabilitative Therapy

CC was prescribed 24 in-office weekly sessions with prescribed home activities encompassing compensatory oculomotor scanning training, sensory-motor integration therapy, and development of deficient binocular and oculomotor skills, in addition to improving the visual processing skills of visual spatial relations, visual memory, and processing speed.

Phase 1

This phase emphasized the development of monocular fixation and transfer to accurate gross pursuit movements. Activities included star fixation, straw and pointer, visual-motor forms, Marsden ball tracking, rotator board, Wayne saccadic fixator board, computer perceptual therapy (CPT) pursuits, Sanet vision integrator (SVI), and Neuro Vision Rehabilitator (NVR). Sweeping gross eye movements into the left field and inferior left field were emphasized in pursuit training with controlled head and body movement with and without prediction. In addition, compensatory oculomotor scanning training with strategizing and target populated left field technique (on SVI, NVR, Wayne saccadic fixator board) was implemented. Stimulation of convergence abilities with suppression checks began with instrumentation such as bead and string and 3-dot card. Peripheral awareness training at near with activities including ET touch and MacDonald cards was prescribed. Visual spatial processing development was prescribed to aid in organizational processing of her altered visual spatial schema status-post her visual field defect. These activities included bilateral integration (Randolph shuffle, chalkboard circles, etc.) right-left hand identification, and sequencing in eye-hand coordination tasks (e.g., bean bag toss, SVI, Wayne saccadic fixator board). Rehabilitation of body image, directionality, visual spatial midline, and visual spatial relations are necessary to reestablish matches between the perceived space and physical reality in conditions of visual field defects or USI.[1]

Progress Evaluation 1 (concluding 8 in-office sessions):

Per CC, she had improved in the following signs and symptoms: rereading lines, skipping words, use of finger to keep place for reading, balance, and posture (Table 3). She noted that although improved, she still experienced some dizziness and disorientation and had no noticeable improvement in peripheral vision. Pertinent objective measures are shown in Table 4, which illustrate her improved distance and near visual acuity of the right eye, DEM performance, and near point of convergence. She

Table 4: Key Findings Pre- and Post-Treatment

	Baseline (Pre-Treatment)	Progress Evaluation 1 (Concluding 8 sessions)	Progress Evaluation 2 (Concluding 16 sessions)	Progress Evaluation 3 (Concluding 24 sessions)	Follow-up assessment (2 months post-treatment)
Visual Acuity Unaided (distance)	OD: 20/50 OS: 20/25	OD: 20/40 OS: $20/30^{-2}$	OD: $20/30^{-1}$ OS: $20/30^{-2}$	OD: $20/50^{+2}$ OS: $20/40^{+2}$	OD: $20/40^{+2}$ OS: $20/25^{-}$
Visual Acuity Corrected (near)	OD: RS 80 OS: RS 30	OD: RS 30 OS: RS 30	OD: RS 30 OS: RS 30	OD: RS 25^{-2} OS: RS 25^{-1}	OD: RS 20^{-2} OS: RS 20^{-2}
Cover Testing (distance)	No movement/ortho	No movement/ortho	No movement/ortho	No movement/ortho	No movement/ortho
Cover Testing (near)	Intermitttent alternate exotropia, 90%, >OS 12-14 pd/6 XP (equal in 9 fields of gaze)	No movement/6-8 XP (equal in 9 fields of gaze)	No movement/6 XP (equal in 9 fields of gaze)	Intermittent left exotropia, <5%, 4-6 pd/4xp (equal in 9 fields of gaze)	No movement/4xp (equal in 9 fields of gaze)
Near Point of Convergence	7/8" OS out, (-) diplopia	3/4" OS out, (-) diplopia	2/3" (+) blur	2/3" OS out, no diplopia reported	4/6" OS out, no diplopia reported
Worth 4 Dot	Flat fusion at distance, intermediate, and near (pulled head away at 5 inches-repeatable) ranges with no movement on unilateral cover test	Flat fusion at distance, intermediate, and near with no movement on unilateral cover test	Flat fusion at distance, intermediate, and near with no movement on unilateral cover test	Flat fusion at distance, intermediate, and near with no movement on unilateral cover test	Flat fusion at distance, intermediate, and near with no movement on unilateral cover test
Gross Pursuits (monoc and binoc)	Full and smooth, 1+ head movement	Full and smooth, no head movement	Full and smooth, no head movement	Full and smooth, 1+ head movement	Full and smooth, no head movement
Gross Saccades (monoc and binoc)	90% gross undershoots, 1+ head movement	Accurate, no head movement	Accurate, no head movement, reports "dizzy"	20% mild undershoots to CC's left field, no head movement	Accurate, no head movement
DEM Test (based on ceiling age of 13.11 years)	Horiz: 28th percentile Error: >60th percentile	Horiz: 60th percentile Error: 60th percentile	Horiz: 60th percentile Error: 60th percentile	Not tested	Not tested
Stereo Acuity Testing	1/4 500", 1/4 250" Randot Stereo, 40" Wirt Circles	Not tested	4/4 500", 1/4 250" Randot Stereo, 20" Wirt Circles	4/4 500", 4/4 250" Randot Stereo, 20" Wirt Circles, 100" Animals	3/4 500", 3/4 250" Randot Stereo, 20" Wirt Circles, 100" Animals
Confrontation Fields	Reduced accuracy and appreciation of inferior left and right quadrants, reduced accuracy and appreciation on patient's left superior and inferior quadrants	Single presentation: full to finger count OD, OS	Single presentation: full to finger count OD, OS	Single presentation: full to finger count OD, OS	Single and simultaneous presentation: full to finger count OD, OS
Fusional Facility	Suspect possible constant OS suppression	Not tested	Not tested	8 cpm	Not tested
Visual Midline (spatial localization)	Not tested	Not tested	Not tested	Not tested	Mild consistent visual midline shift to her right with no significant response to 2-10 pd trials yoked prism base left
Humphrey Visual Field 30-2	Absolute superior left field quandrantanopia defect OD and left superior and temporal hemianopia OS	Absolute superior left field quadrantanopia defect OD and left superior and resolving temporal hemianopia OS (absolute defect in superior quadrant and possible rise of edge border in inferior defect)	Not tested	Not tested	Not tested
Easygraph 24-2 (Sup Thr2) Visual Field	Absolute superior left field quadrantanopia defect OD and left superior and inferior temporal hemianopia OS (showing absolute defect in superior quadrant and dense defect inferior)	Superior left quadrant-anopia OD and decreased size of left hemianopia inferiorly OS (Figure 2)			

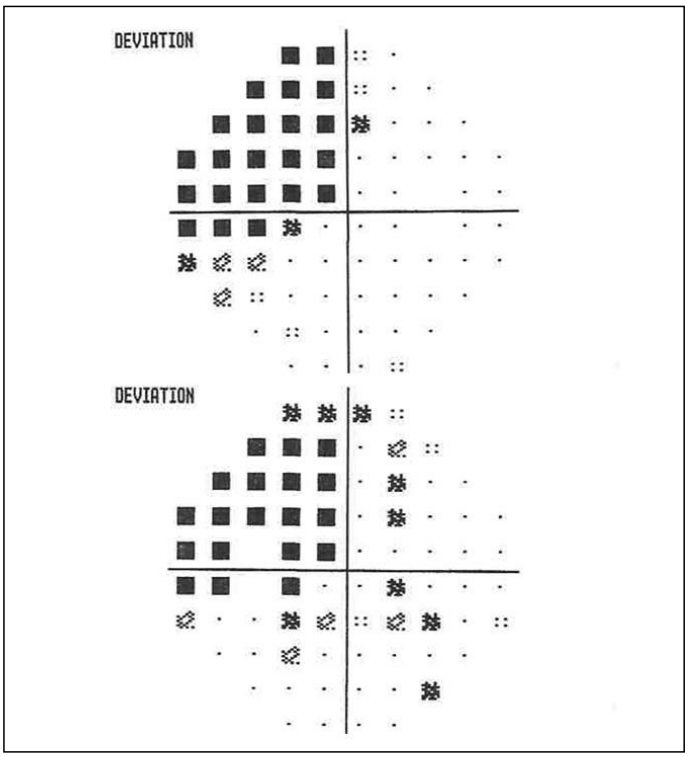

Figure 2. *Post-therapy visual field (top OD, bottom OS)*

also eliminated her intermittent alternating exotropia, head movements during gross pursuits, and gross undershooting during gross saccades. CC was educated about trialing of the sector prism at minimum during vision rehabilitative therapy sessions and again deferred. CC was also educated about the test results and the treatment modifications in her vision rehabilitative therapy program.

Phase 2

Binocular fixation and binocular fine pursuit development ensued with integration of vestibular work on the NVR balance board and standard balance board. Gross saccadic activities were implemented (mastered monocularly and then binocularly). Activities included Hart chart saccades and Track and Read saccades. Voluntary convergence and positive fusional ranges were developed (e.g., tranyglyphs, vectograms, eccentric circles, and Vision Therapy System 3 (VTS3)). Peripheral awareness training extended to intermediate and distance ranges with emphasized work on SVI and NVR programs and included transfer to movement through space (e.g., bean bag toss to peripherally placed targets while walking on walking rail). Visual spatial processing development ensued with focus on directionality activities (e.g., floor map, CPT directionality, stick-tap, etc.); visual memory and visual sequencing processing development was incorporated per CC's complaint of affected memory skills post stroke and included memory activities on Visual Information Processing Skills (VIPS) and multi-matrix.

Progress Evaluation 2 (concluding 16 in-office sessions):

Symptomatology review (Table 3 outlines progression) illustrated that CC was still improving in her reading and balance abilities. She was more stable in her line-dancing but still got dizzy when performing a turn. Table 4 illustrates pertinent objective measures and shows improved unaided distance visual acuity of the right eye, near point of convergence, depth perception, and confrontation field performance.

Phase 3

Emphasis was on fine saccadic activities with processing speed, metronome integration, and cognitive loading (e.g., symbol tracking sequences, spell tracking, percon saccades, etc.). Advanced scanning activities ensued with concentration on left field and integration of processing speed. It has been proposed that for best outcome, processing speed and span of recognition should be maximized along with scanning training.[1] Tachistoscopic and span of recognition development were included through related activities on SVI, CPT, and Track and Read programs. Peripheral awareness with dynamic free space movement and vestibular components were integrated (e.g., windmill finger tracking, wall-spotting turns, step-turn sequences). Positive fusional step vergence, jump ductions, and divergence abilities were developed with movement and peripheral awareness as applicable (e.g., vectograms walking, distance eccentric circle chart walk-aways, etc.).

Progress Evaluation 3 (concluding 24 in-office sessions):

CC ecstatically reported improved side vision and proudly demonstrated her awareness of both of her thumbs simultaneously with her arms stretched out to her sides. She noted that she was enjoying reading again. All presenting signs and symptoms had improved except that CC was still concerned with her difficulties with finding objects that she reported being directly in front of her. She also noted that her memory skills were still reduced. Table 3 shows symptomatology progression. CC noted excessive fatigue during testing due to lack of sleep the night prior, which may support resurfacing of exotropia, although it presented with significantly reduced frequency and magnitude and a shift to unilateral as compared to initial testing. She showed improvement in depth perception and fusional facility. CC deferred the visual field testing recommended. Sectoral and bi-nasal prism trials were administered and again deferred by CC. Maintenance home activities were prescribed, including red and green far-near chart tracking, MacDonald card, and physiological diplopia stick facility. CC was instructed to return in 2 months for a follow-up assessment. She was educated on the importance of compliance with the home maintenance program to prevent regression of developed skills. CC was instructed on the importance of continuing to be monitored by her neurologist, cardiologist, primary care provider, and ophthalmologist.

2-month Follow-up Assessment (completed 24 in-office sessions, moderate compliance with prescribed home maintenance program):

Symptomatology review (Table 3 shows progression) revealed that CC's balance had improved and she could now perform some turns when line-dancing. She reported that her visual field remained intact, and she was no longer surprised by her husband "popping up" in her visual field. CC reported that she was now reading and cooking easily; however, she felt like she still struggled to find things (e.g., her watch sitting on her dresser or a calendar which had been propped up on wall, rather than lying flat).

Table 4 shows pertinent objective data which reveals improved near acuity for both eyes and slightly regressed near point of convergence with no exotropia found. Threshold visual field testing was deferred by CC. Visual midline (spatial localization) testing showed mild consistent visual midline shift to her right with no significant response to yoked prism base left. CC was educated to continue the maintenance home program and to return for a follow-up assessment in 4-6 months (which will include threshold visual field testing). CC was also educated on the importance of repeating visual fields in order to monitor the defect and, if needed, to make any modifications to her treatment plan. She was educated to continue to be monitored by her neurologist, cardiologists, primary care physician, and ophthalmologist. Lastly, she was instructed to continue to utilize scanning strategies and to take safety precautions related to her visual field defects.

Summary

Outcome

The neuro-optometric treatment plan met the goals of both the doctor and the patient, in which CC's functional vision improved. CC was especially elated, expressing extreme excitement that she could appreciate her left visual field and could enjoy reading and line-dancing again.

Diagnostic Reflection

Overall, this case followed expectations with regard to prognostic factors assessed. The visual field gradient border of the left inferior temporal field of the left eye resolved slightly as anticipated, and CC's awareness of her left field significantly improved. Although the initial presenting signs and symptoms and USI testing performed did not yield a manifestation of USI, extinction confrontation fields were not performed; therefore, CC's marked improved awareness of her left field is difficult to gauge. In future related cases, more detailed assessments of USI will be performed at the initial testing, with specific emphasis on the individual's behaviors and conventional and extinction visual field tests, which are key factors in the diagnosis.[2] For further assessment of suspect USI, future history intakes may include the following question: Does it ever seem like one side of your world is missing? CC answered that she did not bump into things when walking and that she did not just eat half of the food on her plate, while her husband said otherwise (varied responses between individuals and family members can be consistent with USI).[4]

Amsler grid testing would have been helpful to measure the extent of a suspected visual defect in relation to central vision, which would have given more functional insight on near tasks such as reading for CC.[4] In addition to providing insight into interventions for reading and writing, Amsler grid testing could have assisted in the performance expectations for search tasks by detecting visual distortions within the macular area and to serve as a measure of the proximity of the hemianopia edge to fixation.[1]

CC noted a significant improvement in her balance abilities, and while the oculomotor assessments of fixation, pursuits, and saccades provided insight into the integrity of the vestibular system, it would have been beneficial to monitor more specific measures of vestibular function. Future related testing may include dynamic acuity, Romberg testing, and routine gait/posture observation. Also, it would have been beneficial to refer CC to an orientation and mobility expert to provide further care.

In retrospect, a baseline of entering visual processing skills would have helped objective measures of progress in this area and would have aided in allowing specific direction of the development of processing skills in the treatment plan. Specific to this case, measures of tachistoscopic skills and span of recognition, processing speed, visual spatial relations, directionality, visual memory, and sequential memory would have assisted the treatment plan direction and progress monitoring. With regard to CC's complaint of difficulty locating objects amongst other objects/backgrounds and in different positions, measures of figure ground, spatial relations, and form constancy would have best assisted her care.

Treatment Reflection

In future related cases of visual field loss, more extensive patient and family education will be performed to highlight the importance of various prism trials for overall success of the neuro-optometric rehabilitation program. Recovery from an ABI can be aided by various uses of prisms.[19] Moreover, future case management will include prism trials outside of the exam room instead of solely in the vision rehabilitative therapy setting, with an emphasis on active closed-loop prism adaptation work with yoked prisms and movement.[19] Furthermore, with regard to prescribed prism for outside-clinic use, more education will transpire to ensure that the patient understands the basis of the prism application and safety while wearing the prism, including a review of the induced blind spot, diplopia, and image parameters while viewing through the prism. Also, specific prism scanning training will be outlined with future cases beginning with static modality mastery to advancement of dynamic modality.

With regard to CC's concerns about balance, it would have been beneficial to prescribe bi-nasal occlusion to determine

whether increased focal-ambient processing may have further aided the progress of her balance abilities. Furthermore, the integration of trials of small-magnitude base left yoked prism into the vision therapy rehabilitation sessions may have also improved balance by shifting the visual midline. In addition, co-management of the balance concerns with occupational and physical therapy treatment plans may have also enhanced gains, especially with appropriate therapeutic lenses in place during those therapies.

Conclusion

A neuro-optometric rehabilitation plan yielded a successful outcome of improving functional vision following a CVA causing visual field defect. Diagnostic scrutiny of visual field defect-related conditions, such as visual midline shift, USI, and focal-ambient integrative processing dysfunction, are crucial for the development of the treatment plan and for monitoring objective progress throughout treatment. Integration of prism into the vision rehabilitative therapy sessions and extensive patient education of applicable prismatic lens options is imperative to achieve maximized benefits from the neuro-optometric rehabilitative treatment plan.

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