An optometric approach to the rehabilitation of the stroke patient

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ABSTRACT—Cerebral vascular accidents cause many visual side effects. A review of these effects will be outlined along with possible rehabilitative techniques to reduce or eliminate these visual problems. A new functional approach to the treatment of ocular-motor dysfunctions and resulting diplopia specifically caused by strokes will be discussed.

KEY WORDS—cerebral vascular accidents, thrombus, embolus, hemorrhage, nystagmus

Optometrists have successfully treated anomalies of accommodation and convergence, strabismus and amblyopia, as well as visual problems associated with learning disorders.[1,2,3,4] After working with patients in a Veterans Administration hospital who have oculo-motor dysfunctions, it became apparent that many visual problems secondary to systemic diseases can also be managed within a functional model of orthoptic visual rehabilitation. Patients who have oculo-motor dysfunctions of systemic origin were previously told to learn to live with their visual problems. Eye patches were frequently suggested in cases of diplopia and near point work was frequently discouraged.

Clinicians who adhere to classical orthoptics have frequently excluded these patients because they did not always fall into their structural model of vision. This model does not accommodate people who do not fit into the classical orthoptic environment or utilize orthoptic equipment. As a result, a segment of our population, including wheelchair patients, stroke victims, and others are not able to receive the appropriate treatment for their visual problems. Many of these people become very depressed because they cannot perform their daily living routines such as reading, cooking, and working. Quite often, secondary behavioral problems also develop.

Optometric philosophy has included the remediation of visual problems by modifying environments and teaching patients to process visual information in "real space." Optometry as a profession offers a lot of help to these patients. By modifying classical visual therapy techniques as well as adding new procedures specifically designed for these patients, visual rehabilitation of stroke victims as well as problems resulting from other systemic diseases can successfully be accomplished.[5]

This paper will first review the visual changes associated with many systemic diseases with the major emphasis on the visual changes associated with cerebral vascular accidents. Finally, functional optometric rehabilitative techniques and sequences available to victims suffering from strokes will be suggested.

A stroke is defined as a sudden attack of ischemia (a localized deficiency of blood) or a hemorrhagic disorder of the brain often resulting in a neurological problem. Strokes are currently the third leading cause of death in the United States today.[10] There are two main types of strokes:

a. those caused by thrombi (the formation in blood vessels or in the heart of a blood clot) or emboli (occlusion of some part of the cardiovascular system by the impaction of a foreign mass transported to the side through the bloodstream) and

b. those caused by hemorrhages. Visual characteristics of those caused by thrombi or emboli include a sudden, instantaneous loss of vision, which is usually unilateral and painful. Visual characteristics of strokes caused by hemorrhages are gradual, non-predictable, bilateral losses of vision.

The signs and symptoms of cerebral vascular accidents include amaurosis fugax (transient monocular blindness), CRA occlusion, branch artery occlusion, incongruous homonymous hemianopsia, cotten wool spots, widening of arteries and veins, embolic plaques, decreased CRA pressure, diplopia, and reading difficulties, and memory disturbances.

Basic visual processes include accommodation, convergence, motilities, fusion, stereopsis, and visual perception. Difficulties can arise in any of these areas resulting in focusing problems, aiming or pointing anomalies, motility errors, strabismus (loss of binocular vision) and visual field losses. Since the

TABLE 1

Patient Symptoms—Professional Observations and Possible Area of Visual Dysfunction

Convergence Problems (Pointing System)	**Accommodation Problems** (Focusing System)	**Motilities** (Tracking System)
—closing one eye	—focusing problems	—inability to follow objects smoothly
—double vision	—headaches	—reading problems
—muscle palsy	—pain	—skipping words
—headaches	—double vision	—re-reading words
—pain	—squinting	—reversals
—reading problems	—closing one eye	—nystagmus-regular, rapid, involuntary movement or rotation of the eyes
—print blurry	—reading problems	
—ocular discomfort	—ocular discomfort	
Strabismus (Eye-Turn)	**Visual-Perceptual**	**Field Defects**
—closing of one eye	—problem judging size	—bumping in chairs, objects, etc.
—double vision	—problem judging distances	—difficulty seeing at night
—head tilts or head turns	—coordination problems	—tunnel vision
—sudden onset of eye turn	—left-right confusion	—holding on to walls, other people, etc.
—muscle palsy		
—difficult judging depth and three dimensional viewing		

ye is part of the central nervous system and has a rich blood supply, systemic diseases affecting the CNS or interfering with vascular efficiency can affect the visual system and its pathway.

Testing

The case history of a patient having had a stroke should include a careful history of previous cerebral vascular accidents, the patient's present medical history including drug therapy, the patient's ocular history, and ocular symptoms.

A thorough optometric evaluation of a stroke victim should include:

a. careful case history to include signs and symptoms in six areas of possible visual dysfunction (see Table 1) as noted by the patient or other observors.
b. professional observation. (These are observations of signs of which the patients may be unaware ... e.g. head tilt (Table 1)
c. a refractive analysis including an evaluation of binocular vision at distance and near
d. ophthalmoscopy
e. a complete visual field analysis including:
   (1) central fields
   (2) peripheral fields
   (3) binocular peripheral fields
   (4) monocular fixation of view (have the patient follow a moving target on an arc perimeter and measure how far the patient can view the targets in all positions) and a binocular fixation of view without diplopia. These tests serve as objective measurements of pretherapy baseline data. Following optometric intervention, these tests can be redone to see if:
   (a) muscular spasms such as contractions or pareses have been eliminated or reduced.
   (b) the field of monocular excursion has been extended or
   (c) the field of single, binocular vision has been increased. As a result of pre- and post-therapy testing, the success of therapy can be determined objectively and quantitatively.
f. a thorough external evaluation including a cover test, motilities, and pupillary reflexes
g. a test for nystagmus
h. a perceptual motor battery including copy forms (adult variety and add a three dimensional target to be copied) a reading test, pegboard test, circus puzzle, picture identification test,[11] object identification test,[12] the Jordan Left-Right Test,[13] and the Motor Free Visual Perception Test.[14]

Since visual performance is affected by:

a. the ability to perform output motor tasks (i.e. fusional vergence movements, eye-hand coordination activities, or oculomotility tasks), or
b. the ability to integrate information at a cortical level (i.e. spatial organization), a perceptual-motor battery should be performed. From our experience with children having visual problems which affect learning, we feel both of these areas can be enhanced through a sequenced therapy program utilizing sensory-motor interaction or orthoptic visual training for the development of basic visual skills. When dealing with stroke victims however, we feel that although motor output problems can be successfully enhanced within the framework of any physical limitations that may be present, spatial concepts may be more difficult to re-develop if trauma has occurred to areas of the central nervous system controlling the integration of sen-

TABLE 2
Visual Changes Associated with Cerebral Vascular Accidents

1. Visual field losses including
   a. total losses
   b. sector losses
   c. central losses
   d. peripheral losses
   e. congruous and incongruous, homonymous defects
   f. altitudinal losses
2. Diplopia due to the non-comitancy of the binocular alignment
3. Nystagmus
4. Lagophthalmus
5. Visual hallucinations
   a. formed variety (trees)
   b. unformed variety (stars, bolts)
6. Anisocoria
7. Frequent headaches
8. Loss of fixation
9. Convergence insufficiency
10. Accommodative problems
11. Reading difficulties (usually the earliest sign)
12. Visual perceptual losses including:
    a. disturbances in body images
    b. disturbances of spatial relationships
    c. Agnosia (difficulty in object recognition)
    d. Apraxia (difficulty in manipulation objects)
    e. Right-left discrimination problems
13. Memory losses

sory information. Therefore, it is important for the practitioner to probe the areas of output motor performance and cortical integrative ability when examining a stroke victim. The above battery was established to serve this purpose. If there are visuomotor problems, tests are presented which systematically eliminate the motor component of the task demand in order to help the practitioner identify which area is most affecting performance. An example of this would be the Motor Free Test which probes form perception without motor involvement while the Copy Forms Test probes form perception dependent upon motor involvement. It is beyond the scope of this publication to describe how to use this information to make a differential diagnosis. We refer those interested readers to the bibliography at the end of this article.

It has been reported that 20% of all stroke victims suffer some visual problems.[15] Classically, strokes affect one eye and one side of the brain; however, cerebral vascular accidents affecting both eyes have been reported.[16] Table 2 lists thirteen visual changes associated with strokes.[6,7,8,9] It is important to remember that all patients do not have to have anomalies in all of the mentioned areas. The location of the cerebral vascular lesion will determine which area of visual performance is affected. (See Table 2)

Review of treatment

After a thorough evaluation of the problem, visual rehabilitation or re-education of the stroke victim should be considered. It is best to isolate each area of disturbance and list the possible rehabilitative techniques that can be considered to alleviate patient problems.

a. Visual field defects—
   1. Training on head rotations to compensate for the disability. The patient must learn to move his head in the direction of the loss. Objects should be placed in the areas of the visual field loss, and not placed on the patient's side, forcing the patient to rotate his head across the affected side. Success will depend on frequency and persistence.
   2. Prism placed in the direction of the field loss.
   3. Mobility training
   4. Teaching the patient eccentric viewing if a central field problem exists.
   5. Optical Aids
      (a) central losses—all kinds of magnifying aides, telescopes, and proper illumination
      (b) peripheral losses—reverse telescopes, hand magnifiers, CCTV and proper illumination
      (c) assorted non-optical aids (large print books, large telephone dials)

b. Ocular misalignment and oculomotor dysfunction:
   1. orthoptic visual therapy (to be discussed fully later)
   2. prisms
      (a) as an adjunct to orthoptic visual training, or
      (b) to temporarily restore binocular vision
   3. lenses
      (a) as an adjunct to orthoptic visual therapy
      (b) to temporarily restore binocular vision
   4. combination of the above

c. Nystagmus
   1. fixation training
   2. contact lenses
   3. plus lenses
   4. prisms
   5. magnification devices
   6. pleoptics

d. Lagophthalmus
   1. artificial tears
   2. soft contact lenses
   3. ointments

e. Headaches—check to see if these headaches relate to other visual problems such as convergence insufficiency or accommodative problems.

f. Perceptual problems—training involves a re-education of body awareness, visuospatial orientation, and object recognition. Training includes:
   1. retraining body image
   2. left-right discrimination training
   3. laterality and directionality awareness
   4. two- and three-dimensional coordination

Illustrative case report

A 65-year-old patient was recently examined in our optometric binocular vision clinic at the Northport VA Medical Center. Mr. M. suffered a stroke six months prior to this visit, and his chief complaint was double vision, mainly on right gaze. The following is a summary of our workup:

1. eye movements; jerky with limitations on abduction and adduction in his right eye.
2. cover test: right hypophoria at distance and near, with an intermittent right exotropia at 16 inches.
3. pupillary reflexes: sluggish, but within normal limits.
4. tonometry and ophthalmoscopy: within normal limits.
5. distance corrected visual acuity—
   OD −2.00 −50 × 90 20/20
   OS −2.25 − 075 × 90 20/20
   with constant diplopia on right gaze.
6. near point findings:
   a. +2.00 add, determined by dynamic cross cylinder testing, correcting near acuity to 20/20 O.U.
   b. phorias through the +2.00 add: 2 eso and ½ BD OS
   c. ductions through the +2.00 add
      (1) Base In (divergence): X/6/−2
      (2) Base Out (convergence): Suppression
7. Motor Fields Testing: diplopia most apparent on right gaze; however, while in primary position, the diplopia was intermittent. The patient exhibited a head tilt to the right.
8. Convergence near point: 6/8 inches OS out, and diplopia reported.
9. Park Three Step: possible right superior rectus palsy.
10. Worth Four Dot Test: five lights at 16 inches, with exo projection.
11. Normal visual fields
12. Normal responses on perceptual-motor testing

Discussion

Unless there is reason to believe otherwise, it can be assumed that prior to their cerebral vascular accidents, patients had some degree of fusion and possibly stereopsis. Since the majority of these patients yield diplopia rather than active suppression, the awareness of their double vision as sensory feedback can be utilized when teaching the patient to realign his eyes. Sensory fusion consists of establishing superimposition, flat fusion, and stereopsis, while motor fusion is the ability to maintain fusion and stereopsis by making both positive and negative fusional vergence movements. The use of feedback to monitor sensory and motor fusion has been successfully used in strabismus and amblyopia. Since suppression is usually not active with stroke patients the double vision or bi-circuit awareness can be utilized as a positive rehabilitative element. The following sequence has been utilized in the therapy program for stroke patients because it offers certain clinical advantages:

a. All treatment is performed in "real space." Fusional training can more easily be performed in the fields of gaze in which the patient does not have limitations.
b. These techniques serve as effective home training exercises.
c. The equipment needed in the sequence is relatively inexpensive.
d. The equipment is not sophisticated. Elderly patients can understand what they are expected to see and do.
e. Patients having physical limitations, i.e. wheelchair patients or patients having drug induced side effects, will not fatigue as easily during this training.

Therapy

The following is an overview of the therapy program performed successfully on our stroke patient, Mr. M. Basic techniques to enhance ocular motility and fixation skills, accommodative facility and hand-eye coordination were performed. The following sequence is specific for the development of clear, single, binocular vision in all fields of gaze.

Phase I-Bi Circuit Awareness (Fig. 1)

A piece of red filter paper is placed either on a window or on a gooseneck lamp so to be lit from behind. An appropriate window should be chosen so as to allow the patient to look through to a distance target. If a pair of red/green glasses is worn, the eye with the red filter will see the red target, and the eye wearing the green filter will see a black target. The patient, as well as a family member, should be taught this principle so that bi-ocular comparison can be experienced. This is a very gross, peripheral task, allowing the patient to compare what each eye is seeing; hence the start of binocular awareness through feedback. At this stage, the patient is told to move his head until the two images fuse into one. The field of gaze which yields fusion will be the starting point of establishing binocular vision in all gazes. If the patient exhibits better fusion at near during this diagnostic work-up, this technique should be performed up close. The patient is instructed to move his head into different fields of gaze, always maintaining the proper binocular response. If a separation of the images occurs, or if any part of the target turns black, the patient has immediate feedback and should make a head turn to regain fusion. This is an ideal home therapy technique and is why we initially suggested teaching it to a family member.

Phase II—Controlled Superimposition (Fig. 2)

A large hole is placed in the center of the red plastic and this hole is replaced by a piece of green plas-

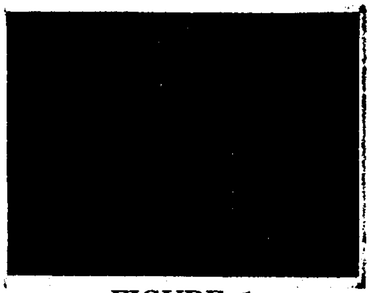

FIGURE 1

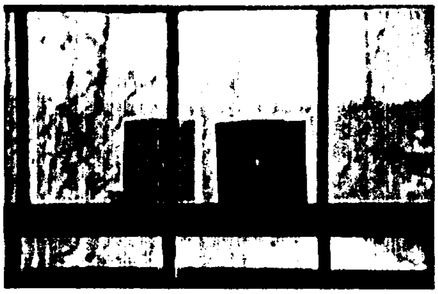

FIGURE 2

FIGURE 3

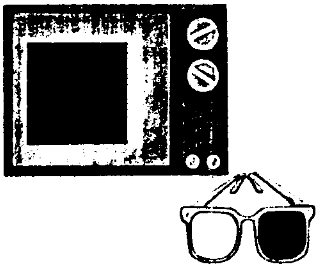

FIGURE 4

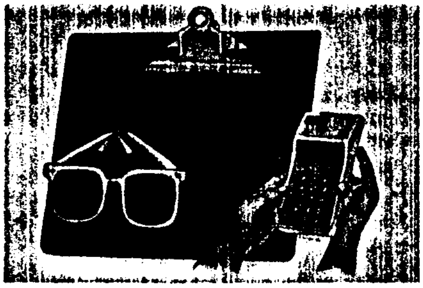

FIGURE 5

tic. At this stage, one eye is seeing a large, red, peripheral target, while the other views a smaller, more central green target. The eye with the red filter will view the red plastic and the eye with the green filter will view the green circular target. The patient's goal is to project the green circle in the center of the red plastic. The patient is instructed to turn or tilt his head or look either closer or further than the window in order to achieve superimposition. Again, during this technique the patient will be receiving proprioceptive feedback which will serve as learned feedback. Once the patient is successful at this stage, the green circle can be made smaller and smaller; thus, the task demand becomes more central. If a large deviation exists, we can use prisms to determine the subjective angle by having the patient center the green hole in the red plastic. This method yields a practical prism prescription for use during therapy which aids the patient to fuse. Diplopia is eliminated and so is the need for an eye patch. The goal is to reduce the prism through the development of expanded fusional ranges.

Phase III—Controlled Fusional Awareness

The next phase is to add three pieces of black tape onto the plastic set-up used in Phase II. Two pieces are placed on either side and the third is placed right through the center of the red paper; the tape should extend beyond the paper. A green hole should be placed in the tape as illustrated in Figure 3.

The black strips serve as a binocular lock. The goal, at this stage, is to see a single target, with a green hole in the center of the black tape. If any part of the target turns black, the patient is told to blink and concentrate. If the center green hole is not perfectly centered, the patient should either look farther or closer and/or turn or tilt his head, thus using the past learned proprioceptive feedback. If this technique is successful, the patient can perform jump duction techniques, by looking away and then back at the target, always maintaining the proper binocular responses. This is intended to develop fusional facility.

Phase IV—Fusional Facility Development

In this stage, loose prisms are introduced for two reasons. First, if the patient was given prism in his prescription to maintain fusion and alignment, loose prisms will be used as tools to reduce the prescribed prisms. For example, if 30 prism diopters BO was prescribed, a loose 2 prism diopter BI can be introduced and the patient must maintain fusion and alignment (on the target described in Phase III) by making a motor response. As the amount of introduced prism is gradually increased, the amount of prism prescribed can be reduced.

If no prism was prescribed, loose prisms will be introduced and used to maintain binocular fusion and develop fusional ranges. Again the patient will experience sensory-motor feedback and thus establish fusional responses.

Phase V—Dynamic Fusional Development

Since many stroke victims have non-comitant deviations, using a single target as in Phase IV will constitute passive training and not directly simulate activities that patients face in daily living such as reading and walking.

a. A series of these targets (as used in phase IV) is placed around a room and the patient is instructed to look at each target, maintaining the responses. This will reinforce dynamic active binocular saccadic eye movements through space with sensory motor fusional controls.

b. Eight of these targets are placed in a Lite Brite (Figure 4). While wearing red/green glasses, the patient will place red and green pegs in alternate holes without ever letting anything on the eight targets go out of alignment. Thus the patient will begin to redevelop eye/hand coordination associated with binocular posture.

c. A calculator which lights up red is obtained. White paper with black numbers is set up under a piece of green filter (Figure 5). The patient must look at the numbers through the red/green glasses and plus and minus lenses are used to facilitate the accommodative response. The patient clears the numbers, punches the calculator to light up the numbers he sees and the numbers are added on the calculator. The patient then removes the red/green glasses and re-adds the numbers. If they get the same answer, they have succeeded in this task. This serves as a dynamic means of re-establishing accommodative facility.

Patients with strokes often cannot effectively perform in instruments because they cannot tilt or turn their heads. To overcome this, the above techniques, may be utilized in eccentric fields of gaze. In addition, Brock strings can be utilized in different gazes. Vectograms moved into off-centered directions also serve as adjunct to the above therapy sequence.

Following four months of therapy (16 one-hour in-hospital visits combined with a home therapy program) utilizing the above sequences, Mr. M. was dismissed with the following results;

1. Cover Test—right hypophoria of 1Δ at distance and near, and on exophoria (10 prism diopters) at 16 inches.
2. Near Point Findings:
   a. + 200, determined by dynamic cross cylinder testing, correcting near acuity to 20/20
   b. phorias through the + 200 add:1 eso and ½ BD OS
   c. ductions through the add
      (1) Base In (divergence): 18/20/14
      (2) Base Out (convergence): 16/20/12
3. Motor Fields:
   Fusion on all fields of gaze; Mr. M. no longer exhibited a head tilt.
4. Convergence Near Point: 3/4/ OS out, exo diplopia
5. Worth Four Dot Test: Four lights at all distances

During the post-therapy evaluation, Mr. M. expressed satisfaction with his therapy program. He no longer sees double on right gaze and is now able to read for extended periods of time without experiencing any asthenopic symptoms. Mr. M. was given the following prescription

OD −200 −050 × 90
OS −225 −075 × 90 1Δ BD
OU +2.00 Add

and placed on a three-month recall.

Our functional heritage allows optometry to come to the aid of these special patients. By utilizing our basic knowledge in binocular vision and perception, classical sequences can be modified to help people who have special problems. Many systemic disorders causing visual problems can be treated with optometric orthoptic visual rehabilitation. By expanding our model of functional vision, patients who have been previously told that their systematically related visual problems cannot be helped, may now look to optometry for guidance and remediation. By understanding ocular problems associated with systemic diseases, we are able to accurately question and test patients and develop training sequences to restore and enhance their functioning in a visual world.

AOA

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