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Vision therapy for oculomotor dysfunctions in acquired brain injury: A retrospective analysis

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KEYWORDS
Acquired brain injury;
Oculomotor dysfunction;
Vision therapy;
Eye movements;
Reading;
Quality of life

Abstract

BACKGROUND: Oculomotor dysfunctions are among the most common abnormalities found in the brain-injured population. The purpose of the current study was to determine retrospectively the effectiveness of conventional optometric vision therapy for oculomotor disorders of vergence and version in a sample of ambulatory, visually symptomatic, predominantly adult outpatients who had either mild traumatic brain injury (TBI) or cerebrovascular accident (CVA).

METHODS: A computer-based query for acquired brain injury patients examined between the years of 2000 and 2003 was conducted in our clinic. This yielded 160 individuals with mild TBI and 60 with CVA. Of these patients, only those for whom vision therapy was prescribed and who completed an optometric vision therapy program for remediation of their oculomotor dysfunctions were selected. This included 33 with TBI and 7 with CVA. The criterion for treatment success was denoted by marked/total improvement in at least 1 primary symptom and at least 1 primary sign.

RESULTS: Ninety percent of those with TBI and 100% of those with CVA were deemed to have treatment success. These improvements remained stable at retesting 2 to 3 months later.

CONCLUSION: Nearly all patients in the current clinic sample exhibited either complete or marked reduction in their oculomotor-based symptoms and improvement in related clinical signs, with maintenance of the symptom reduction and sign improvements at the 2- to 3-month follow-up. These findings show the efficacy of optometric vision therapy for a range of oculomotor abnormalities in the primarily adult, mild brain-injured population. Furthermore, it shows considerable residual neural plasticity despite the presence of documented brain injury.

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Oculomotor dysfunctions are among the most common vision problems found in the general population presenting to the optometrist.[1-4] These include abnormalities of version, vergence, or accommodation. Presence of such problems can produce a variety of visual performance deficits, such as slowed reading and impaired visual search.[5] Fortunately, there is evidence showing success with optometric vision therapy in these cases, with both objective and subjective evidentiary documentation,[2,5] including a recent randomized clinical trial for the condition of convergence insufficiency in adults.[6]

Oculomotor dysfunctions are also among the most common vision problems in individuals with acquired brain injury (ABI).[2,3] In fact, a recent large-scale retrospective study documented that approximately 90% of individuals

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with either a mild traumatic brain injury (TBI) or a cerebrovascular accident (CVA) manifested some type of oculomotor dysfunction after the acute phase of care.[7]

There is a small but growing body of evidence showing successful treatment of oculomotor deficits in the TBI and CVA populations.[5,8-10] Although the reported percentages of successful treatment have been high, many were either case reports[11,12] or case series.[6,8] However, some small-scale, prospective population studies have been conducted showing objective improvements and high success rates using either electrophysiologic[13] or eye movement measures.[10] Despite the above studies, large-scale investigations remain warranted.

Thus, the purpose of the current study was to determine retrospectively the effectiveness of conventional optometric vision therapy for oculomotor dysfunctions in a relatively large sample of ambulatory, visually symptomatic, predominantly adult outpatients having either a mild TBI or a CVA.

Methods

A computer-based query was obtained for ABI patients examined between October 1, 2000, and October 7, 2003, using either the 99203 (new patient evaluation) or 99213 (established patient evaluation) procedure codes. All patients were ambulatory, predominantly adult (all but 3 were older than 18 years of age) outpatients with associated vision-based symptoms. Optometrists from the Raymond J. Greenwald Rehabilitation Center (RJGRC) at the State University of New York (SUNY) State College of Optometry performed the vision examinations. The majority of patients were referred by rehabilitation professionals from the following institutions: Rusk Institute of Rehabilitative Medicine at NYU Medical Center, Bellevue Hospital at NYU Medical Center, Department of Rehabilitative Medicine at Mount Sinai Medical Center, Lenox Hill Hospital, New York Hospital, and the International Center for the Disabled. Other referrals were made by rehabilitation professionals in private practice in the greater New York City area. Referrals were also received from other services within the college's University Optometric Center including primary care, low vision, contact lens, and ocular disease and special testing. Referred patients were not limited to those with either a TBI or CVA; individuals with other neurologic conditions that affect the visual system, such as vestibular dysfunctions, cranial postsurgical complications, and brain tumors, comprise a sizeable patient base.

The RJGRC's diagnostic evaluation included assessment of the following areas: visual acuity, distance and near refraction, distance and near binocular and oculomotor status, color vision, visual fields, and ocular health. In some instances, not all of these areas could be evaluated fully because of limitations in the patient's cognitive status, language ability, and/or physical state.

The computer query yielded 486 records of which 300 were selected randomly. Each of 3 members of the RJGRC's clinical staff (coauthors D.R., S.C., and M.E.H.) then randomly chose 100 of the records. Of these, only those patients with either a mild TBI (n = 160) or CVA (n = 60) were reviewed. Of the above 220 selected patients (with an age range of 11 to 80 years), only those who had been recommended and completed a full course of optometric vision therapy for accommodative, versional, and/or vergence oculomotor dysfunctions at the time of the computer query were incorporated in the analysis.

Regarding TBI, 144 of 160 presented with oculomotor signs and symptoms. Of those 144, only 87 were recommended for vision therapy, with the remaining 57 persons deemed inappropriate for vision therapy because of excessive fatigue factors, too many other concurrent therapies, unstable systemic/neurologic health, severe cognitive deficits, and/or behavioral issues.

Of the 87 with TBI who were referred for vision therapy, 59 followed the recommendation. Of those 59, only 33 had completed vision therapy at the time the analysis was performed, with 26 still in progress.

Regarding CVA, 52 of 60 presented with ocular motor signs and symptoms. Of those 52, only 23 were recommended for vision therapy, with the remaining 29 persons deemed inappropriate for vision therapy for the reasons stated above for TBI. Of the 23 with CVA referred for vision therapy, 15 followed the recommendation, whereas 8 did not. Of the 15 with CVA who followed through with vision therapy, 7 had completed vision therapy at the time the analysis was performed, with 8 still in progress. Therefore, a total of 40 patients were included in this study: 33 TBI and 7 CVA. This study excluded the results for those patients who were still in training at the time of analysis and classified as being "in progress" at the time.

Table 1 summarizes the age and postinjury years in terms of mean, standard deviation, and range. Note that although the sample population was predominantly adult, 3 11-year-old individuals were also evaluated and treated with

Table 1 Patient demographics and diagnostic breakdown for TBI (n = 33) and CVA (n = 7)

	TBI	CVA
Parameter		
Mean age (y) at initial visit	42.3	56.6
Standard deviation of age (y) at initial visit	15.2	20.3
Range of age (y) at initial visit	11-66	29-80
Mean years after injury	3.2	1.1
Standard deviation of years after injury	4.1	0.6
Range of years after injury	0.25-20.17	0.6-2.2
Diagnostic category		
Strabismus	3	2
Phoria	29	5
Accommodative deficit	3	1
Oculomotor deficit	31	7
Visual field defect	12	5

Table 2 Categories of oculomotor symptoms and signs

Symptom
Blur
Diplopia
Impaired global sense of depth perception
Increased sensitivity to visual motion (caused by oculomotor-based impairment of dynamic version and/or vergence)
Eye strain
Headache
Avoidance of near vision tasks
Oculomotor-based reading difficulty (e.g., loss of place when reading, skipping lines when reading, and misreading or missing words when reading)
Difficulty with global scanning (e.g., problems navigating in busy streets, stores, malls, etc.)
Sign
Reduced amplitude of accommodation
Increased lag of accommodation
Reduced relative accommodation
Slowed accommodative facility
Uncorrected hyperopia/astigmatism (caused by inability to compensate)
Receded near point of convergence
Restricted relative convergence (BO) at far and near
Restricted overall fusional vergence ranges at far and near
Abnormal Developmental Eye Movement (DEM) test results
Low grade-level equivalent performance on the Visagraph II
Impaired versional ocular motility

vision therapy. Table 1 also summarizes the number of patients with strabismus, phoria, accommodative deficits, versional oculomotor deficits, and visual field defects.

A summary of the symptom and sign categories is presented in Table 2. This included a wide range of areas dealing specifically with the oculomotor subsystems of version, vergence, and accommodation.

Conventional vision therapy paradigms were used.[4] This included vergence, version, and accommodative therapy (Table 3). Accommodative therapy was only incorporated in the treatment plan for the 4 individuals who were younger than 40 years and manifested an accommodative deficit: 3 with TBI (2 11-year-old patients and 1 38-year-old patient) and 1 with a CVA (a 29-year-old patient). Those older than 40 years had either markedly reduced or absent accommodation (i.e., presbyopia), and thus vision therapy was not prescribed for their accommodative deficits. Table 4 presents tabulated data describing the number of vision therapy sessions conducted over a 2- to 8-month period. The criterion for treatment success was either marked improvement or normalization of at least 1 primary symptom and at least 1 primary sign. The former was based on a 3-category, symptom specification: no improvement, some improvement, and marked/total improvement, as is typically done clinically. The latter was based on the clinical signs moving toward the appropriate compensatory values or, in the absence of a heterophoria, the normative values in the literature.[14-16]

Results

Symptoms and signs: Mild traumatic brain injury

Symptoms reported in the mild TBI patients are presented in Table 5. The most common symptoms were oculomotor-based reading difficulty, eyestrain, diplopia, and headaches. Signs found in the mild TBI patients are also presented in Table 5. The most common signs were receded near point of convergence, abnormal Developmental Eye Movement (DEM) test results, and reduced near convergence range.

Symptoms and signs: Cerebrovascular accident

The only symptom reported in the CVA patients is presented in Table 6. This was oculomotor-based reading difficulty, which was found in all of the individuals. Signs

Table 3 Training areas

Vergence oculomotor
Small disparity steps to increase the fusional range
Small disparity ramps to increase the fusional range
Large disparity steps to enhance fusional vergence facility
Large disparity steps with opposing accommodative demands to enhance fusional facility
Sustained vergence at different disparity demands
Versional oculomotor
Stationary target to enhance fixational oculomotor stability
Predictable horizontal, vertical, and oblique steps to enhance saccadic accuracy
Predictable horizontal and vertical ramps to enhance smooth pursuit accuracy
Visual scanning to enhance detection of targets in one's environment
Visual search to enhance detection of targets embedded within a complex array
Accommodative
Monocular stationary target to determine and enhance accommodative stability
Monocular predictable small, moderate, and large dioptric step changes to enhance the accommodative facility, accuracy, and sustainability over time (performed in free space and/or using loose lenses)
Monocular predictable small, moderate, and large dioptric ramp changes in the accommodative stimulus to enhance the accuracy and sustainability of gradual changes in accommodation (performed in free space and/or using loose lenses)
Binocular (with suppression control) predictable small and moderate dioptric step changes to enhance the accommodative facility, accuracy, and sustainability over time (performed in free space and/or using loose lenses)
Binocular (with suppression control) predictable small and moderate dioptric ramp changes in the accommodative stimulus to enhance the accuracy and sustainability of gradual changes in accommodation (performed in free space and/or using loose lenses)

Table 4 Vision therapy patient information

Subgroup	Total completing vision therapy	Total improving after vision therapy	Number of sessions			
			10-14	15-20	21-25	26-30
TBI	33	30	4	9	10	12
CVA	7	7	3	4	0	0

found in the CVA patients are also presented in Table 6. These included impaired versional ability and abnormal DEM. Each sign was found in all 7 patients.

Treatment improvement: Mild traumatic brain injury

Thirty of 33 (~90%) showed either complete or marked reduction in 1 or more of their primary symptoms. Twenty-seven of 30 (90%) showed either marked improvement or normalization in 1 or more of their primary clinical signs.

Treatment improvement: Cerebrovascular accident

All 7 (100%) showed either complete or marked reduction of their only primary symptom. All 7 (100%) exhibited either marked improvement or complete normalization of their 2 primary signs.

Table 5 Symptoms/signs initially reported by patients with TBI (n = 33)

	Number of patients reporting the symptom/sign
Symptom	
Ocular motility difficulty when reading	27
Eyestrain	18
Diplopia (at near more so than far viewing distances)	18
Headaches	11
Visual fatigue	5
Near blur	3
Sliding together of text words	1
Increased sensitivity to visual motion	1
Avoidance of near tasks	1
Sign	
Receded near point of convergence	23
Abnormal DEM test	23
Reduced near convergence (BO) range	16
Reduced near vergence ranges	9
Binocular suppression during testing	3
Impaired versional ocular motility	2
Nausea during near testing	1

Note: some patients may have presented with more than 1 symptom/sign.

All patients were reevaluated 2 to 3 months after the termination of vision therapy. Their symptoms and signs remained stable.

Discussion

This has been the first relatively large (n = 40) and comprehensive retrospective analysis of oculomotor dysfunctions in a visually symptomatic, ambulatory, predominantly adult mild ABI sample, which incorporated the 2 primary subgroups of mild TBI and CVA. The current findings showed a wide range of vergence, versional, and accommodative problems that could be remediated successfully, at a level of 90% or better, incorporating conventional optometric vision therapy in the affected oculomotor areas.[14-16] Both symptoms and signs, with most being related to near vision activities, were either markedly reduced or totally eliminated. These findings suggest the presence of considerable visual system plasticity in response to the targeted vision rehabilitation in this brain-injured sample. Thus, despite the presence of brain damage in this predominantly adult population, considerable improvement in oculomotor skills was evident.

The current study is complementary to our earlier retrospective investigation involving the frequency of occurrence of oculomotor problems (~90%) derived from this same initial clinic sample.[7] This earlier study included a wider age range and sample size (11 to 80 years of age, n = 220), of which these 40 individuals made up a subgroup. In both the present mild TBI and CVA subgroups, vision therapy resulted in symptom and sign reduction as well as

Table 6 Symptoms/signs initially reported by patients with stroke (n = 7)

	Number of patients with the symptom/sign
Symptom	
Ocular motor difficulty when reading	7
Sign*	
Impaired versional ocular motility	7
Abnormal DEM test	7

* Some patients may have presented with more than 1 sign.

related subjectively based reading improvements per the case history.

The current results show that optometric vision therapy can be an important modality in the vision rehabilitation of those with acquired brain injury having oculomotor dysfunctions. Except for those with strabismus, these patients can be regarded simply to be more difficult and challenging "oculomotor skills cases." Many of the signs and symptoms, as well as the basic therapeutic paradigms, are similar.[6,17,18] However, progress may be slower and more variable, perhaps attained with a lesser level of final improvement. In addition, the vision therapy may be hindered by memory and cognitive deficits as well as physical health setbacks. Despite these potential obstacles, based on the current findings, a 90% "success" rate is impressive. Although all patients may not normalize, the improvements can be considerable. Thus, given the constellation of both vision-based and non–vision-based residual problems in this population,[18,19] it is important for the optometrist to attempt a regimen of vision therapy, with likely symptom reduction.

In addition to performing vision therapy in the ABI population to improve their numerous oculomotor deficits and related symptoms,[5] it can also exert a broader positive influence on the overall quality of life (QOL). Furthermore, the presence of residual vision problems, including oculomotor deficits, will adversely affect other forms of rehabilitation.[20,21] Thus, such oculomotor deficits would hinder one's overall rehabilitative progress. For example, presence of accurate and steady fixation as well as efficient saccadic tracking is required in many aspects of cognitive therapy, such as completing a complex visual search matching task.[22]

Lastly, there are several areas of future investigation that should be explored in this population. First, a large prospective analysis is warranted. This would allow for better control of the therapeutic components and overall case management, such as specification of precise and consistent times allotted for each category of procedure on all patients. In addition, a control group that did not receive vision therapy would be included. Second, the therapeutic "dose" effect should be studied. That is, what are the minimal amounts and types of vision therapy procedures that yield the best short- and long-term effects with respect to related oculomotor symptoms and signs? And, related to this, does the improvement transfer to other domains, such as general and visual attention? Third, there is the need for long-term follow-up, perhaps up to 1 year or more. And, lastly, the impact of successful vision therapy on one's QOL should be assessed formally. It is important to determine quantitatively the effect of vision therapy on the patient's vocational and avocational goals. In this way, both the personal and socioeconomic impact can be ascertained with respect to the individual's overall satisfaction level.

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