BRAIN INJURY, 1993, VOL. 7, NO. 5, 439–448

Incidence and treatment of visual dysfunction in traumatic brain injury

K. SCHLAGETER, B. GRAY, K. HALL, R. SHAW, and R. SAMMET

Santa Clara Valley Medical Center, San Jose, CA 95128, USA

(Received 12 July 1992; accepted 17 August 1992)

The incidence of visual dysfunction and effectiveness of visual exercises in acute traumatically brain injured inpatients in a rehabilitation programme were studied. Vision evaluation norms were established on 23 hospital staff. The evaluation was then administered to 51 inpatients within days after admission. An additional 21 patients were unable to participate, usually due to decreased cognition or agitation. Thirty of 51 (59%) scored impaired in one or more of the following: pursuits, saccades, ocular posturing, stereopsis, extra-ocular movements, and near/far eso-exotropia. For patients having dysfunction in pursuits or saccades, a 2-week baseline was followed by vision exercises. During the baseline interval patients were evaluated by an optometrist to verify therapists' findings. Six patients who participated in several weeks of treatment were evaluated at 2-week intervals by an independent rater. Progress is graphically illustrated. Conclusions were that the suitability of an inpatient vision programme, from our experience, is questionable. However, an initial evaluation proved valuable for informing staff of patients' visual status and for referral to an optometrist/ophthalmologist for further treatment.

Introduction

A traumatic brain injury (TBI) may significantly impact a previously intact and functional visual system. Visual disturbances in TBI patients have been described in the literature for over 40 years [1]. The effectiveness of vision therapy for these individuals has only recently been addressed.

The visual system is vulnerable to injury from the cornea to the visual cortex [2]. However, damage to the visual system following a TBI is most likely the result of cranial nerve damage or direct trauma to the orbital content [1, 3]. Additional areas of injury include the optic chaism, optic tract [4] midbrain [1, 5, 6] and cortical structures [7, 8]. Padula identified characteristics and symptoms commonly observed following a TBI, and labelled this condition the post-trauma vision syndrome. [9]. Visual problems commonly noted following a TBI include: reduced distance or near acuity, field cuts, strabismus (with exotropia being most common), phoria, oculomotor dysfunction, convergence insufficiency, accommodative dysfunction and impaired depth perception [4, 10–13].

Incidence

While the presence of visual disturbances following head injury is well documented [2, 4, 5, 7, 8, 14–16], few studies examine the incidence of ocular disorders

Address correspondence to: Karyl M. Hall, Ed.D., Santa Clara Valley Medical Center, 751 South Bascom Avenue, San Jose, CA 95128, USA.

This study was funded by the National Institute on Disability and Rehabilitation Research, Dept. of Education.

in TBI patients. Gianutsos and her colleagues [11] reported that 50–65% of severely impaired TBI patients in a long-term rehabilitation facility had visual disturbances significant enough to support further evaluation. Cohen *et al.* [1] reported vergence difficulties in 10/26 (38%) acute TBI patients. A follow-up study of 72 patients who were approximtely 3 years post-injury identified vergence insufficiencies in 42% of the cases. Mitchell *et al.* [14] found strabismus in 23 of 29 patients with the most frequent complaint being diplopia and diplopia with blur.

Treatment

Multiple-treatment approaches in use with other disabilities are being applied to the TBI population as awareness of visual problems is increasing. Treatment alternatives include vision therapy or corrective surgery. Therapeutic options include patching, lenses, and vision exercises.

Vision exercises consist of a series of activities designed to increase the patient's awareness of his/her visual deficits and increase function while maximizing residual vision. Vision exercises are most frequently recommended to address oculomotor disorders, diplopia and partial vision loss [11, and R. Neger, personal communication]. Various exercises are designed to specifically target paretic muscles [R. Neger, personal communication] or to incorporate the use of lenses or prisms into an activity to encourage the interaction between the sensory and motor systems [6].

Vision professionals, physiatrists and rehabilitation team members are requesting evidence of the efficacy of vision treatment strategies. At present, most of the available documentation on vision training with neurologically impaired patients is provided by single case studies. Berne [13] presents three TBI case studies in which 6 months of individual vision therapy at 1 hour per week resulted in less exophoria at near, a reduction in near point of convergence and an increase in positive fusional reserves. Krohel *et al.* [7] studied 26 closed-head trauma patients with traumatic convergence insufficiency. Treatment consisted of convergence exercises and prisms. Response to therapy was variable and often incomplete. Cohen [17] reports on a 42-year-old patient who sustained a left cerebrovascular accident resulting in a third nerve paresis, and constant diplopia secondary to a left exotropia/hypotropia. He reports the elimination of all associated visual symptoms following 4 months of training of unknown intensity. Similar results are cited on a 52-year-old closed-head injury patient with horizontal and vertical diplopia. Exercises were conducted daily for 5–10 minutes over a 3-month period with reports of slow elimination of the horizontal diplopia [18].

The efficacy of vision therapy has not been specifically researched with respect to time post-injury, frequency and duration of treatment, or specific deficit areas amenable to intervention. Its appropriateness and applicability for the TBI population, and how that may interface with a total rehabilitation programme, requires further exploration.

The present study was initiated to assist in clarifying some of the issues surrounding this complex problem. The purpose of the study was to answer the following questions:

(1) What is the incidence of visual dysfunction in TBI patients admitted to an acute inpatient rehabilitation programme?
(2) Does treatment improve visual function of TBI patients, specifically for pursuits and saccades?

Methods

Subjects

The patients selected for the study had sustained a traumatic brain injury (TBI), stayed in inpatient rehabilitation for at least 1 week, and were able to reliably complete the visual evaluation. Additionally, for those on whom visual treatment data were collected, a minimum inpatient baseline plus vision treatment period of 4 weeks was required.

Normative data were collected from a group of 23 volunteer individuals, mostly hospital staff, all without significant visual histories by verbal report. They were given the visual evaluation by the same two therapists who completed the patient evaluations.

Design

A single case pre- and post-test design was used for those who had a minimum of 2 weeks of vision treatment. Each patient was his/her own control. Two baseline measures were obtained before treatment began, separated by a 2-week interval when possible. It was impractical to extend the baseline beyond 2 weeks because of limited hospital stays.

All visual evaluations were spaced 12–14 days apart, starting with the initial evaluation and continuing every other week until study discharge. The study design is illustrated as follows:

	2 week baseline No treatment		Treatment				
Week:	1	2*	3	4	5	6	7
	1st visual eval.		2nd visual eval.		3rd visual eval.		4th visual eval.

*consult: optometry

Procedure

Rehabilitation admissions who met study criteria received a visual screening from the occupational therapist (OT) or speech pathologist (SP), usually within 1 week of admission. If the patient could not complete a visual evaluation at that time (e.g. cognitively too impaired), rescreening occurred at 1-week intervals until the patient was able to be admitted to the study.

All study subjects with visual complaints (as determined by the visual history questionnaire) or probable deficits (as determined by the visual evaluation) were referred to the optometrist (OD) and evaluated within 2 weeks of referral.

If acuity was very poor and thought to affect task performance on pursuit, saccade and alignment tests, patients were considered untestable. Treatment began following the receipt of recommendations from the OD and following completion of the baseline visual evaluation. As soon as feasible, the patient's acuity was corrected if indicated. Formal exercises were not assigned outside of treatment sessions.

Study subjects were discharged from the vision programme when discharged from the inpatient rehabilitation programme.

Each patient was assigned one treating clinician and one of two evaluators for the entire programme. The tests are believed to be free of re-test learning.

Nevertheless, to minimize the potential practice effect of repeated testings, the tests were administered in random order.

Types, dosages and dates of medications given that might affect visual performance were documented from medical chart review for those six patients on whom long-term data were collected.

Measures

The measures used in the study were as follows:

(a) Visual history questionnaire
(b) Visual evaluation
(c) Functional assessment measure (FAM), [19].

The OT/SP visual evaluation tool was developed collaboratively with an OD and included the following tests (the definitions of normal/abnormal limits are included in **bold** lettering):

(a) Near/far acuities, each eye
20/40 and beyond = abnormal
(b) Extra-ocular movements, each eye
< 90% = abnormal
(c) Pursuits ratings, each eye
1 = profound impairment
2 = severe impairment
3 = moderate impairment
4 = mild impairment (considered normal in this study)
5 = normal
(d) Saccades ratings, each eye
(Same ratings as for pursuits)
(e) Ocular posturing, each eye
Maddox rod test:
1. near eso-exophoria
eso: > 4 prism dioptres = abnormal
exo: > 8 prism dioptres = abnormal
2. near hypo-hyper phoria
> 1 prism dioptre = abnormal
Cover test:
3. near eso-exotropia
4. far eso-exotropia
any indication of eso/exotropia by observation = abnormal
(f) Stereopsis
> 60 seconds of arc = abnormal/absent

Visual evaluation reliability

Normative data on 23 subjects were obtained. Average age was 36 years and 16 of the 23 were female. A visual history questionnaire ruled out all subjects with questionable visual problems (other than acuity). Subjects were given the visual evaluation using the same instructions and procedures as the patients were given.

Pursuits were normal (5) in all cases except for a score of 4 in five cases of 46 (23 subjects × 2 eyes). Saccades were normal (5) in all cases but two of 46, which were rated a 4. These findings clarified the need to include 4 and 5 ratings as within normal limits for both pursuits and saccades. Vertical and horizontal eye alignment were within normal limits in all cases for both eyes.

Inter-rater reliability among vision therapists was established. Pearson correlations were run between the two raters, an OT and an SP, on pursuits and saccades measures for patients. The correlation for pursuits was 0·87 and for saccades was 0·86, on a sample of 68 and 67 eyes respectively. The percentage agreement yielded 92% correspondence for pursuits when the 4 and 5 categories were collapsed (both considered normal), and 82·5% for the saccades measure.

Results

Sample description: average age of the group of 51 patients who met study criteria was 33·5 years, ranging from 16 to 68 years of age, and 39 (76%) were male. Average length of coma was 4 days, range was 0 to 19 days. Average days from injury to rehabilitation admission were 34·5, range was 6 to 180 days. Injury was sustained by motor vehicle accident in 39% of the sample, motorcycle accident in 22%, and fall in 9·8% of the sample. Educational level was an average of 12·4 years (high school graduate). Marital status was single in 48% of the cases, married in 32% and divorced in 18% of the cases. Average days from injury to visual screening was 58, range was 9 to 190 days.

Upon admission to the rehabilitation programme the averaged FAM rating on a scale of 1 to 7 by treating staff was 3·7 (between moderate and minimal contact assistance). At discharge the average FAM item rating was 6 (modified independence).

The data have been analysed in relation to the two questions initially asked in the study:

(1) *What is the incidence of visual dysfunction in TBI patients admitted to an inpatient rehabilitation programme?*

Seventy-one per cent (51/72) of admissions met criteria for initial visual screening within several days after admission to inpatient rehabilitation (see Table 1). The incidence of visual dysfunction was 59% (30/51). Visual dysfunction for purposes of this study is defined as any abnormal score on any of the tests listed under 'Measures', with the exception of poor acuity.

Type and frequency of visual impairments observed are seen in Table 2.

Table 1. Statistics on initial visual evaluation.

No. of rehabilitation admissions	72
Visual evaluation normal	21
Visual evaluation abnormal	30
Not evaluated/non-study	21
Primary reason:	
low cognitive level	9
unable to cooperate, agitated	5
non-English-speaking	3
rehabilitation < 1 week	3
severe aphasia	1

Table 2. Type of visual dysfunction in TBI rehabilitation inpatients†.

	Number	Percentage
Extra-ocular movements	7/51	14
Pursuits	18/49	37
Saccades	18/48	38
Ocular posturing		
Maddox rod test:		
(1) near eso-exophoria	7/46	15
(2) near hypo-hyperphoria	8/44	18
Cover test:		
(3) near eso-exotropia	19/50	38
(4) far eso-exotropia	12/47	26
Stereopsis	21/46	46

†Sample sizes vary due to behavioural/cognitive/fatigue status of TBI subjects during the evaluation. Test results on a patient were considered abnormal if either eye was impaired.

Table 3. Description of TBI individuals given long-term vision treatment.

	Age	Years Education	Days LOC	Days Inj-Tx	Weeks in Tx	Total Min. Tx	FAM Init-D	Base-discharge Pursuit	Base-discharge Saccade
1	24	11	—	77	6	460	136	0·0	+1·0
2	46	14	19	69	12	940	127	+2·0	+0·5
3	33	14	1	63	12	1160	83	0·0	+1·5
4	48	12	17	60	2	210	106	+1·0	+1·0
5	33	20	5	28	4	440	71	+1·0	+0·75
6	30	13	7	41	4	445	120	+1·5	+0·75

Tx = treatment; LOC = length of coma; Inj-Tx = Injury to treatment; FAM = Functional Assessment Measure; Min = Minutes; Init-D = Initial to Discharge (change score).

(2) *Does treatment improve visual function?*

There were a limited number of cases which could be treated over several weeks time. Six of the 30 patients with visual dysfunction were able, available and appropriate to complete 4 or more weeks of baseline testing and visual treatment before discharge. Visual treatment was not able to be continued on an outpatient basis.

Demographics for the six cases treated and evaluated long term are shown in Table 3. The maximum FAM score (normal) is 210. The FAM column scores in Table 3 reflect the amount of improvement (difference scores) seen between rehabilitation admission and discharge. The pursuit and saccade columns reflect the improvement (difference score) between the best baseline score before treatment and the ultimate discharge score on these measures on a 1 to 5 scale.

To determine if treatment (visual exercises) affected visual function in the areas of pursuits and saccades, a comparison was made between baseline (no treatment) and treatment slopes.

Four of the six cases did not improve in *pursuits* across the baseline period of time (2 weeks), but did show improvement by the final evaluation after treatment. Two showed no improvement over time. Four cases showed no improvement or worsening in *saccades* over the baseline period, but showed improvement during treatment. The two additional cases also showed improvement in saccades, but were missing one of the two baseline measures.

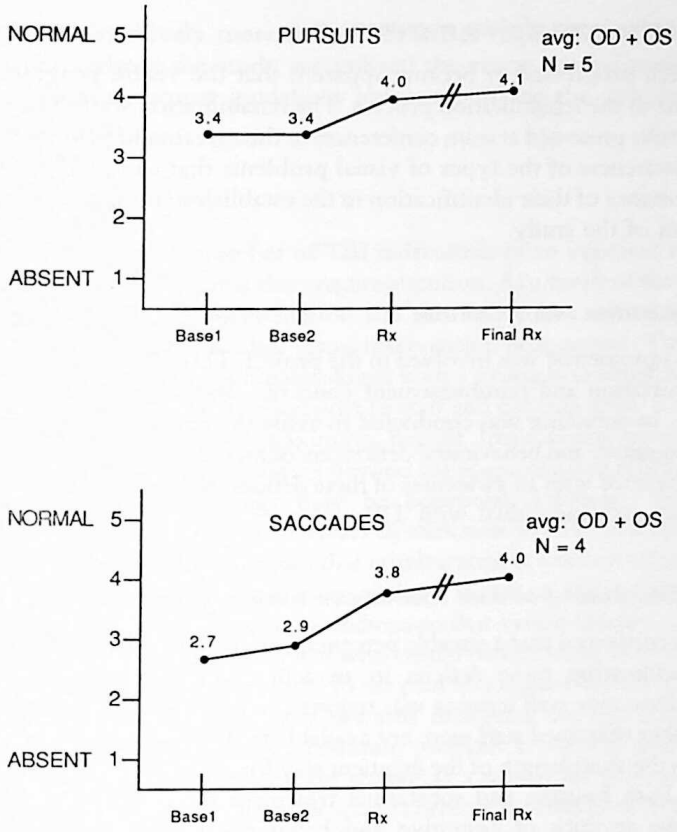

Figure 1. Trends over baseline and visual treatment periods: average ratings for pursuits and saccades.

Composite graphs of trends over time for cases with complete data on pursuits and saccades ratings (left and right eye scores averaged) are shown in Figure 1. The first two data points represent baseline measures without intervening treatment. The third data point represents the evaluation after 2 weeks of treatment and the fourth data point represents the final evaluation after varying amounts of treatment.

Correlations were calculated between total vision therapy minutes given during the study and change scores in pursuits and saccades measures between *best* baseline score and study discharge score for the six cases. Results yielded insignificant findings ($r = -0{\cdot}10$ and $+0{\cdot}31$ for pursuits and saccades respectively). The range of scores was restricted and the sample size small, however.

Medications suspected or known to affect the visual system and/or cognition appeared not to affect progress, as no pattern of visual performance was observed in relation to timing of medications.

Discussion

The vision training programme was initiated as a result of a perceived need to address, in greater depth, the visual problems of TBI patients. Beyond obtaining incidence figures, our ultimate goals were to explore the efficacy of visual exercises and develop an appropriate screening tool and regimen of visual exercises for use with TBI patients.

Positive impact of vision programme

As the research progressed, it became apparent that the vision programme was an important part of the rehabilitation process. The rehabilitation staff utilized the vision evaluation results presented at team conferences in their treatment planning. The overall increase in awareness of the types of visual problems that can plague TBI patients, and the importance of their identification in the establishment of treatment plans was an outgrowth of the study.

Interaction with optometrists

An in-house optometrist was involved in the project. This facilitated communication, eased transportation and reimbursement concerns, and allowed timely optometric consultation. In-servicing was conducted to assist the optometrist in understanding the specific cognitive and behavioural deficits encountered in acute TBI, so that findings could be interpreted with an awareness of these deficits. Generally, 1 hour was required for evaluating each individual with TBI.

Limitations of an acute rehabilitation vision programme

While it was confirmed that a sizeable percentage of the TBI population display visual problems, addressing these deficits in an acute rehabilitation setting presented difficulties. Extensive staff training was required to provide vision treatment, and the limited number of trained staff were not available to devote time for outpatient vision care. Due to the short length of the inpatient stay for many individuals it was difficult to provide both baseline and substantial treatment prior to scheduled discharge. Likewise, the severity of cognitive and behavioural deficits presented by TBI individuals at the acute level influenced their appropriateness for vision services.

Design/results considerations

The inclusion of a 2-week baseline period, although a shorter time than desired, allowed for the measurement of spontaneous recovery. The premise was that spontaneous improvement was expected to be most significant in the early stages of the patient's recovery. The data indicate that improvement during the baseline period was negligible, but followed a treatment regimen several of the patients achieved oculomotor improvement.

No obvious relationships emerged among improvement in pursuits and saccades and the factors listed in Table 3. The non-significant correlation between the total amount of treatment time and the patients' changes in oculomotor dysfunction did not indicate that intensity of visual intervention was related to degree of improvement. It could be that everyone received more than the minimum therapy required to impact their visual performance. More likely the sample size was simply too small. The optimum therapeutic intervention intensity, once efficacy of the approach is established, is yet to be clarified.

Several patients did realize an increase in their visual skills after a 'no-change' baseline. Which exercises are most helpful in facilitating these changes is a question to be explored in future research. Staff were trained in a variety of exercises which were specifically adapted for the TBI population. It became clear to us that establishing

a hierarchy of progressively more difficult exercises required a significant amount of training. Throughout the study we utilized the vision professionals extensively in obtaining initial treatment guidelines and in modifying the exercise regimen as treatment progressed.

Summary

It appears that a significant number of TBI individuals in an inpatient rehabilitation programme have visual problems that require attention. As a result of the observations made during programme implementation and data collection, several points would significantly aid in creating the ideal visual intervention programme. The availability of an in-house optometrist or ophthalmologist with a strong neurological background would allow ongoing consultative support to staff and patients alike. It appears that, for this population to achieve maximum benefit from visual intervention, the opportunity to continue vision services beyond the scope of acute rehabilitation into outpatient or post-acute settings may be beneficial. Likewise, the ability to comprehensively address all types of visual dysfunction would assist in maximizing patient recovery. Finally, the assurance that reimbursement issues would not impinge upon service delivery would allow more patients access to vision therapy.

The results of this study provide an indication that vision therapy may improve performance. Answers to the questions of who would benefit most, how much therapy is required and the exercises most suited to the problem require further investigation. An important first step has been taken towards answering the myriad of questions on the topic. Visual dysfunction is a common problem in the TBI population, but is often overlooked in the rehabilitation setting as a reason for poor performance. Even addressing such basic problems as acuity correction could positively impact an individual's functional level. Results suggest that interventions for specific visual dysfunctions are beneficial and in need of further attention from the rehabilitation community.

References

1. COHEN, M., GROSWASSER, Z., BARCHADSKI, R. and APPEL, A.: Convergence insufficiency in brain-injured patients. *Brain Injury*, **3**(2): 187–191, 1989.
2. ELISEVICH, K. V., FORD, R. M., ANDERSON, D. P. *et al.*: Visual abnormalities with multiple trauma. *Surgical Neurology*, **22**: 565–575, 1984.
3. NEGER, R. E.: The evaluation of diplopia in head trauma. *Journal of Head Trauma Rehabilitation*, **4**(2): 27–34, 1989.
4. TIERNEY, D. W.: Visual dysfunction in closed head injury. *Journal of the American Optometric Association*, **59**(8): 614–622, 1988.
5. HARRISON, R. J.: Loss of fusional vergence with partial loss of accommodative convergence and accommodation following head injury. *Binocular Vision*, **2**(2): 93–100, 1987.
6. PADULA, W. V., SHAPIRO, J. B. and JASIN, P.: Head injury causing post trauma vision syndrome. *New England Journal of Optometry*, Dec: 16–21, 1988.
7. KROHEL, G. B., KRISTAN, R. W., SIMON, J. W. *et al.*: Posttraumatic convergence insufficiency. *Annals of Ophthalmology*, **18**: 101–104, 1986.
8. ELSTON, J. S.: Traumatic third nerve palsy. *British Journal of Ophthalmology*, **68**: 538–543, 1984.
9. PADULA, W. V.: Post-trauma vision syndrome caused by head injury: a behavioral vision approach for persons with physical disabilities. (Optometric Extension Program, Santa Ana), pp. 167–185, 1988.

10. KADET, T. S.: Visual rehabilitation in traumatic brain injury. Paper presented to the National Head Injury Foundation Sixth Annual National Symposium, 8–12 December, 1987.
11. GIANUTSOS, R., RAMSEY, G. and PERLIN, R.: Rehabilitative optometric services for survivors of acquired brain injury. *Archives of Physical Medicine and Rehabilitation*, **69**: 573–577, 1988.
12. BOUSKA, M. J. and GALLAWAY, M.: Primary visual deficits in adults with brain damage; management in occupational therapy. *Occupational Therapy Practice*, **3**(1): 1–11, 1991.
13. BERNE, S. A.: Visual therapy for the traumatic brain-injured. *Journal of Optometric Vision Development*, **21**: 13–16, 1990.
14. MITCHELL, R., MACFARLANE, A. and CORNELL, E.: Ocular motility disorders following head injury. *Australian Orthoptic Journal*, **20**: 31–36, 1983.
15. ROCA, P. D.: Ocular manifestations of whiplash injuries. *Annals of Ophthalmology*, **4**(1): 63–73, 1972.
16. UZZELL, B. P., DOLINSKAS, C. A. and LANGFITT, T. W.: Visual field defects in relation to head injury severity. *Archives of Neurology*, **45**: 420–424, 1988.
17. COHEN, A. H.: Visual rehabilitation of a stroke patient. *Journal of the American Optometric Association*, **49**(7): 831–832, 1978.
18. BECKER, J., FOX, L. and GIANUTSOS, R.: Single-case experimental assessment of vision therapy for bidirectional diplopia secondary to head trauma. *Archives of Physical Medicine and Rehabilitation*, 1 October, 1987.
19. HALL, K. M.: Overview of functional assessment scales in brain injury rehabilitation. *Neurorehabilitation*, **2**(4): 97–112, 1992.