ELSEVIER

NeuroRehabilitation 6 (1996) 183–192

NeuroRehabilitation
An Interdisciplinary Journal

Rehabilitation of traumatic brain injury with associated visual dysfunction — A case report

William M. Ludlam*

College of Optometry, Pacific University, Forest Grove, OR 97116, USA

Abstract

A step-by-step case report describes the rehabilitation program for visual dysfunction of a 52-year-old woman, beginning 2 years post-trauma. Methods to ameliorate such symptoms as diplopia, ocular discomfort, dry eye, inefficient saccadic movement, spasms of accommodation, poor reading comprehension and very limited stamina for near visual tasks are presented. Specific procedures are discussed and results are described and tabulated.

Keywords: Traumatic brain injury; Visual dysfunction; Rehabilitation program

1. Introduction

Recovery from traumatic brain injury secondary to auto accidents, blows to the head, gunshots, poisonings, drowning, cerebral palsy and strokes have all been recorded in the scientific literature [1–6] and increasingly in the newspaper press and popular magazines as well. From this exposure to the general public, the well-documented idea of human neural plasticity has gained acceptance, although the recovery is usually portrayed within more narrow limits than is the case as experienced by many of those active in neural rehabilitation [7]. Much information has been learned and reported on the anatomy and neuroanatomy of the visual system and on the sequelae to this system following trauma [8,9]. This paper reports the recovery of visual and oculomotor function in a 52-year-old female school principal following a severe auto accident 2 years previous, where much evidence of CNS damage (e.g. hematoma, coma and surgical repair) were reported. When formal vision therapy was initiated almost 2 years following the date of the auto accident, much visual and oculomotor dysfunction were still present. This experience violates much of the conventional wisdom in this area, which implies that plasticity and hence recoverability of neural function is limited to the young (pre 20-year-olds) and within a 6-month period of the initial injury [3–4]. This case history is an example that expands the frontiers for visual rehabilitation and recovery, both in terms of patient age and increased time of initiation of therapy following the original insult. In no way is this paper suggest-

* Corresponding author.

ing delay of treatment, but rather expanding any supposed time limitation beyond which both recovery and rehabilitation have been thought to be unlikely or impossible.

Although papers by Warren [12–13] and Schlageter et al. [14] appeared after completion of the therapy of this patient/client, their major conclusions provide a welcome corroboration of the general results and approach utilized in the present case history. The efficacy of vision therapy, the importance of oculomotor control, visual fields, visual acuity, visual attention, scanning, pattern recognition, memory and visual cognition, are all skills measured and trained in the present paper, and addressed by these authors. The concept that certain 'foundation skills' [12] such as oculomotor, acuity and peripheral field, underly the higher level visual perceptual functions complements the rehabilitation approach used in this paper and confirms the results achieved. The basic skills must be intact or functional before higher perceptual skills that include visual memory, visual attention and visual cognition can be improved or normalized.

The training program utilized with this patient was office supervised during approximately monthly visits, with assigned vision therapy to be carried out daily at home. The different home training activities ranged from five to eight procedures per day with a maximum total daily home training time for the therapy not to exceed 40 min. Equipment such as prisms, red-green (anaglyph) glasses, stereoscopes, cheiroscopes and accommodative facility flip lenses [11] needed to carry out much of the therapy regimen were loaned to the patient and returned at the completion of each phase of the training. While a total of 25 office visits were made over a 3-year period, the 21 visits involved directly with the rehabilitation process occurred during a 26-month period. The final four visits at 3-month intervals served as monitoring sessions at which the functional performance of G.Y.'s visual system without further therapy support was evaluated over the final year. The most recent visit at the time of the writing of this report was 8 June 1994.

2. Patient history

G.Y., a 52-year-old female elementary scho principal, was involved in a head-on automobi collision on 4 November 1988. She was in a com initially for 86 h, and then experienced on and o memory lapses and problems with awareness ov the next 3 months. She was operated on fc multiple skull fractures and a life threatenin epidural hematoma the same day. In addition, sh suffered fractures of the sternum, left elbow, le leg and left hip. Both inner ears were filled wit blood, her right ocular orbit was crushed wit multiple fractures and required a plate to b implanted to re-establish the structural integrit of the orbit. Internal cranial pressure in the cas of G.Y. required completion of a craniotom Following this 3-week period of critical care was 6-week tour at a rehabilitation center, wher speech therapy, occupational therapy and gros motor physical therapy were carried out. Th patient's right pupil was fixed and dilated and severe limitation of gaze to the right by the righ eye was limited to the midline. A constant es otropia (crossed eye), following several strabismu surgery attempts to produce alignment (the lates in January 1990), combined with a right hyper tropia (one eye deviating upward), both sequellae of the right orbital fractures. G.Y. experienced a dry right eye caused by an injured right tear gland for which she instilled drops on an hourly basis. She habitually manifested a head turn and tilt to the right in order to avoid diplopia (double vision). Reading also posed a problem, both in terms of comfort and clarity as well as the ability to comprehend the meaning of the material. She was only able to read several pages per day, whereas she had previously been a voracious reader for several hours a day.

3. Initial findings

23 August 1990 *Distance acuity* — corrected with spectacles
R. 20/50
L. 20/20

Near acuity — bifocal-corrected
R. 20/50 (at a 12-inch working distance)
L. 20/20

Ocular alignment (cover test)
D. Corrected spectacle-midline 14° intermittent right esotropia combined with 5° right hypertropia.
N. Corrected bifocal-midline 5° esophoria combined with 4° right hypertropia.

Near point of convergence bifocal 10 inch — diplopia

Ocular alignment 20° to right of midline

D. 35° constant right esotropia combined with right hypertropia.
N. 30° constant right esotropia combined with right hypertropia.
Ophthalmoscope and slit lamp — ocular health
Media clear both eyes. Ocular fundus negative each eye. Right pupil fixed and dilated 8 mm. Left pupil 3 mm — constricts to 2 mm with penlight. Right eye precorneal film dries under slit lamp view. Blinking and lubrication drops necessary to keep it moist.

Versions
Severe limitation of gaze, right eye to right and right eye to upper right. Large increase in esotropia for both positions and with both eyes open. Hypertropia remains unchanged. Thus, a non-comitant (variable angle) strabismus was manifested for different directions of gaze.

Refraction — essentially the same as present glasses
Rx: R. = 1.50 −4.75 × 105, add +2.25
L. = 1.00 −2.25 × 60, add +2.25

Wearing progressive addition lenses with photosensitive tinting. No prism had been prescribed in these glasses.

Confrontation fields
With white bead (3 mm) at 30 cm distance found full field each eye. Normal size and placement of blind spots in each eye.

Accomodation facility
Difficulty clearing +0.75/−0.75 through bifocal

Table 1
Visual problems occurring after T.B.I. in patient G.Y. b visual therapy

Non-comitant esotropia
Diplopia
Poor convergence
Unsteady fixation — reduced best corrected V.A.
Dry eye
Poor fusion ranges
Accommodative dysfunction
Ocular fatigue
Limitation of gaze
Poor quality of fusion and stereopsis
Head turn/tilt
Anisocoria (right pupil dilated)

left and both eyes. Cannot clear with right ey all. Accomodative dysfunction.

Fusion ranges (rotoscope) Head turned to the r Ball and arrow targets 2° BO–10° BO. Dipl found outside this range. Normal expected BI–20° BO.
Prism flip 6° BO–BI
Can fuse reading material with effort thro bifocal with head turned to the right.
Fatigues after flipping four or five times.

4. Visual treatment program

Patient G.Y. presented with 12 types of pr lems involving her visual system 2 years follov the automobile accident summarized from initial two visits. These are listed in Table 1.

Our vision therapy program for G.Y. attemp to rehabilitate 11 of the 12 groups of probl listed. Dry eye was not initially thought to remediable. Every therapy/treatment proced described below was designed to afford the m mum feedback opportunity to G.Y. and the o all approach for each follows.

4.1. Non-comitant (variable angle) esotropia

This problem was thought to be partly mech ical, caused by injury to the lateral rectus mus from the crushing of the orbital walls and pa

neurological due to injury to the sixth nerve which innervates the lateral rectus muscle. Regardless of the basic etiology, the ability of the right eye to be brought over into the right and upper right fields of gaze needed to be improved. Several different approaches were used:

(a) G.Y. was instructed to continuously fixate, initially monocularly and then binocularly, an object which was slowly moved to the right of midline. Some pain was reported, but decreased over several weeks of daily work and the movement of the right eye slowly increased beyond the midline in the right field of gaze (see Table 2 — items 1 and 2 — dextro, to the right, and supradextro, up and to the right, version). Slow pursuits.

(b) G.Y. was asked to fixate an object (e.g. a face or T.V. screen) and slowly rotate the head to the left and cover the left eye in order to move the eye into the right and upper right fields of gaze.

(c) G.Y was then asked to hold her head steady and perform abrupt ocular fixation movements from an object 10° to the left of her midline to an object situated 20° to the right of her midline. Again, pain occurred initially, which was alleviated with a warm, wet face cloth held over the closed eye for periods of 1–2 min. This approach aided the above two training techniques in improving right eye movement beyond the midline to the right and upper right.

(d) In addition, three-prism B.O. in each eye was prescribed in G.Y.'s spectacles to make

Table 2
Oculomotor binocular function and accommodative skill changes over time

		1st Visit 8/23/90	4th Visit 12/12/90	8th Visit 4/23/91	12th Visit 10/16/91	15th Visit 2/4/92	19th Visit 10/7/92
1	Dextro version	midline	8–10° beyond midline	15° beyond midline	25° past midline	25° past midline	25–30° past midline
2	Supra dextro version	midline	5–8° beyond midline	12° beyond midline some pulling	15° past midline	20° past midline	25–30° past midline
3	Accommodation facility	+075/−075 difficult	+075/−100	+100/−125 clears easily	+125/−125 clears easily	+150/−125 clears easily	+150/−150 clears easily
4	Fusion range (rotoscope)	2–10 BO	0–12 BO	2 BI–9BO	6 BI–12 BO	8 BI–14 BO	10 BI–16 BO
5	Near point of convergence	10 inch diplopia	8 inch diplopia	7 inch diplopia	5–6 inch diplopia	5–6 inch diplopia	3–4 inch diplopia
6	Stereo acuity	none on Wirt test alt. supp.	third target areas supp.		7th target no supp.	8th target no supp.	
7	Prism rock	5 ΔBO–BI	8 ΔBO–BI	10 ΔBO–BI	12 ΔBO–BI	12 ΔBO–BI	12 ΔBO–BI
8	Distance V.A. best corrected	R 20/40⁻ L 20/25⁻	20/30⁻ 20/25	20/20⁻³ 20/20	20/20⁻³ 20/20	20/20 20/20	20/20⁻¹ 20/20
9	Near V.A. best corrected	R 20/50 L 20/25	20/30⁻ 20/25	20/25 20/20	20/20⁻ 20/20	20/20 20/20	20/20 20/20
10	Distance phoria (glasses)	14 eso	12 eso	10–12 eso	11 eso	8 eso	5–6 eso
11	Near phoria (bifocal)	9 eso	7 eso	4 eso	4 eso	3 eso	3 eso
12	Pupil size difference room light conditions anisocoria	R 8 mm L 3 mm	R 7 mm L 3 mm	R 6 mm L 3 mm	R 6 mm L 3 mm	R 5 mm L 3 mm	R 5 mm L 3 mm

fusion easier and reduce her habitual head turn to the right used to avoid the ocular malalignment and diplopia in the right field of gaze.

4.2. Diplopia (double vision)

Similar to the above described approach, the emphasis was now placed on maintaining single fused binocular vision to the right of the midline. G.Y. was asked to wear red-green glasses over her spectacles in order to 'label' the visual field of each eye to foster simultaneous binocular perception and control for ocular suppression (blocking the transmission to the brain of one image) if an eye deviated even slightly from alignment.

(a) Again, wearing the red-green glasses over her spectacles, a target penlight could be moved to G.Y.'s right or upper right and G.Y. was asked to maintain single vision with a mixture of red and green colors (luster).
(b) The head was to be turned to the left or lower left with red-green glasses over her habitual spectacles while G.Y. maintained fixation of the light, mirror or black and white TV screen and attempted to keep the image single with mixed colors.
(c) Saccadic movements to the right and upper right of G.Y.'s midline were to be carried out, again trying to maintain single vision with mixed colors.

4.3. Convergence

A light, pencil or pen was held along G.Y's midline which she viewed through her bifocals. The object was moved toward her nose while she attempted to keep it single. It was much easier for her to keep it single while holding the advancing object because of the additional proprioceptive information when received from the position of her own hand. It was more difficult when the object was held by the therapist and advanced toward her. We assigned both methods for home training. G.Y. was better able to bring the object closer with her hands and converge on it and keep it single than to hold the objects in her hands and advance her head toward it while trying to increase convergence and maintain single vision.

4.4. Unsteady fixation

This was especially noticeable in her right eye, which had the poorer monocularacuity measurement (20/50 initially). Patching of her left eye with glasses was assigned to 30-min periods daily, employing a foveal after-image, during which time reading, watching TV and colouring in small letters in a column of newsprint was used to provide feedback to G.Y. on the stability of her foveal fixation [10]. The regular improvement in both right eye distance and near visual acuity, as seen in Table 2, attests to the success of this approach in producing steadier right eye fixation and improved acuity.

4.5. Dry eye

This condition was believed to be caused by injury to the lacrimal gland above the right eye. G.Y. was advised to keep using the lubricating drops as often as she felt she needed them to avoid dry feeling in the right eye. She was also advised to daily mildly massage the area of the lacrimal gland through the closed upper lid. In Table 3, under item 4, it can be seen that lubricating drops are now needed only two times/day compared to 2–15 times/day initially.

4.6. Fusion ranges

These are an indication of the quality and stamina of binocular vision as demonstrated by the ability to overcome prism with bases in various directions.

(a) In instruments, e.g. stereoscope, telebinocular, rotoscope and major amblyoscope. Here, targets can be widely separated, which is a stimulus for increased divergence, to achieve fusion (single binocular vision) and close

together targets are a stimulus for increased convergence for fusion. The targets can usually be brought closer to the observer, increasing the stimulus for accommodation, and further away, thus decreasing the stimulus for accommodation. Work on a range of target separations at near and far distances increased the fusion range for binocular vision. There can be problems to transfer these skills to ordinary visual space and thus out of instrument training is employed.

(b) Out of instruments: the use of prisms can transfer the increased fusion ranges learned in instruments to everyday seeing conditions. Prisms were used initially to help G.Y. to fuse at different distances with red-green glasses if suppression of one eye was encountered. The red-green glasses were eliminated after several weeks of training when suppression no longer posed a problem.

4.7. Accommodative dysfunction

While some reduction in the accommodative function (focusing for near distance) occurs with the natural process of maturation, G.Y., at the age of 52, had a much larger loss than expected in her left eye and an even greater loss of facility in her right eye. The approach used was with accommodative rock flip lenses where plus lenses are located on one side of a handle (a stimulus to inhibit accommodation) and minus lenses (which stimulate accommodation) on the other. G.Y. was asked to hold these up in front of her bifocal. The plus lenses induced her to relax the muscular effort to focus, clear the reading material, and read for a sentence or two. At that point, a flip of the lenses was called for, and minus or concave lenses were placed in front of the bifocal. These essentially reduced the power of the bifocal and called for an increase in muscular effort to focus. G.Y. was then asked to hold focus at this level for

Table 3
General status of vision

	1st Visit 8/23/90	4th Visit 12/12/90	8th Visit 4/23/91	12th Visit 10/16/91	15th Visit 2/4/92	19th Visit 10/7/92
1 Reading comfort	Has to read and re-read to understand	Reading now better, clearer, comprehension good	Reading with Rx good comprehension	Reading with glasses easier, enjoys more	Reading doing very well, comfort and comp. good	Good comp. and comfort reading
2 Reading stamina	Can only read for 15-min period very tiring distractible	Reads regularly for 25–30 min sessions	Can read for 45 min at a time easier reading more now	Can read for over an hour with no symptoms	Reads with good comprenhension for up to 2 h. Doing well in MS program	Reading span now unlimited
3 Driving vision	Vision blurry and indistinct very fatigiung		Seeing better while driving lately	Driving vision quite good	Driving vision clear and stable	Vision while driving doing well
4 Eye comfort	Eyes very dry and tired a lot Drops 12x/day. Frequent double TV not good	Eyes feel much better after home vision therapy Still dry	Eyes feel very much better after home VT TV watching better	Eyes quite comfortable almost all the time	No discomfort around eyes any more Still dry Drops 4x/day	Eyes dry vision lubricant Drops 2x/day
5 Double vision	Seeing double a lot- especially to right, driving and walking	Some double vision looking way to right	In everyday seeing no double vision	No double vision in every day life	Double vision gone	No double vision ever

two sentences and then to flip back to the plus lenses to again relax the muscular effort to focus. This procedure was usually carried out for a 5-min period with both eyes. The improvement over time can be seen in Table 2, item 3, which shows the increase of the lens combination that could be cleared from ± 0.75 initially to ± 1.50 at the 19th visit. This improvement in focusing ability also can be seen in Table 2, item 9, where best corrected near acuity went initially from R. 20/50, L. 20/20 to R. 20/20, L. 20/20 at the 19th visit, 14 months later.

4.8. Ocular fatigue

This was thought to be caused by G.Y.'s case by items 6 and 7 above. That is, poor fusion ranges and poor accommodation facility and their interaction in the accommodative-convergence relationship. Fusion ranges and accommodative facility can be worked on simultaneously in a stereoscope, mentioned earlier. Here, the separations of the targets being moved can stimulate divergence when wide target separations are employed and convergence when using narrow target separations.

(a) By moving the stereoscope slide holder containing the targets closer to and further away from G.Y.'s eyes (tromboning), accommodation can be stimulated and the convergence and divergence stimulus varied as well. In everyday life, accommodation and convergence are linked so, as an object in non-instrument space moves closer, both accommodation and convergence increase. As the object moves further away, accommodation reduces and the eyes diverge from their converged position. In the stereoscope, when wide separation targets are moved closer, the two functions are trained to disassociate, i.e. accommodation accompanied by divergence. When the slide containing the wide separation targets is moved farther away, accommodation is relaxed and convergence increased. Also, large range, vigorous ocular calisthenics have been found in many patients to reduce ocular fatigue. G.Y. reported on many occasions that her eyes felt much less tired after completing sustained large rotary ocular movements.

(b) G.Y. was instructed to face a wall halfway across the room and to sequentially fixate each corner of the room in clockwise fashion for ten cycles every day. If pain occurred, she was advised to cover the closed eyes with a warm wet compress, in which case the pain and discomfort were reduced. She was then asked to repeat the 'baseball' rotations in a counter-clockwise direction for ten cycles each day. Pain was reduced and was eliminated by the 4th session, and her reports of reduced fatigue following this technique occurred regularly.

4.9. Limitation of gaze

G.Y.'s limitation of gaze to the right and upper right caused an habitual head turn to the right, in order to avoid this field of gaze, has been discussed earlier under non-combatant esotropia and diplopia. With regard to increasing the field of gaze, we undertook to generalize the skill trained earlier by the techniques of prism fixations and cover-uncover-recovery.

(a) G.Y. was asked to fixate an object in front of her, e.g. facing a TV screen, trying to keep it single (fusion) and slowly rotating the head about a vertical axis to the left and right, trying to extend the movement in both directions. A prism held before either eye, base-out or base-in, further tends to generalize the result. The head can then be rotated about a horizontal axis (through the ears) and G.Y. was asked to maintain single vision. The final step is to maintain steady fixation and rotate the head clockwise and counter-clockwise, her nose describing a circle in the air. All of these activities were assigned for her to do 10 times each, daily. If suppression was a problem, the use of red-green, as described earlier, to monitor binocularity was employed.

(b) Cover-uncover-recovery along the midline

was mentioned earlier and is now generalized laterally and vertically, also. Here, G.Y. was instructed to cover one eye with a cupped hand, viewing an object along the midline, e.g. clock face, human face, TV screen or light switch. After covering for 3 s, with the eye underneath the cover open all the time, the hand is rapidly removed and G.Y. was asked whether she appreciated a double image of the object viewed. If she did, she was asked to rapidly bring the double objects together by effort or blinking. When this skill worked well along the midlife, G.Y. was asked to turn her head slightly, e.g. 5° to the left, repeat, and then 5° to the right of midline. When fusion recovery was regular and rapid, the chin could be raised 5° and lowered 5°, repeating the cover-uncover-fusion recovery sequences. The extent of head turn can be slowly increased to 10°, 15° and 20° from the primary straight ahead position left, right, up and down.

4.10. Improve quality of fusion and stereopsis

Binocular vision not only enables the superimposition into a single fused image of the transmission of the two individual eyes to the brain, but it enables the viewer to extract information about a third dimension from these two slightly different views of an object in space by the two eyes. This critical interpretation of the disparity in the two images to give a depth experience is called stereopsis. This is a skill that can be trained in instruments and in space, and both approaches were employed with patient G.Y.

(a) Out of instrument approaches involve polaroid techniques called vectographs and red-green glasses called anaglyphs. Both of these separate the two disparate images to produce a single image with depth. In separating the two images by different amounts, various amounts of disparity create different degrees of depth perceived.
(b) In instruments such as the stereoscope, telebinocular, major amblyoscope and rotoscope, two targets are presented and are seen uniquely by each eye, due to the presence of a midline septum. Different amounts of disparity in the images allow different amounts of depth to be perceived. Using pointers before each eye helps the precision of depth or stereoacuity to be further refined and the quality of binocular fusion to be improved.

4.11. Head turn / tilt

This compensatory position comes about due to the patient's inability to bring about binocularity in the presence of strabismus with a straightforward position. The synergic system described by Moore and Nelson [8] assists in this compensation so that the patient turns toward a direction of possible fusion in order to avoid diplopia. In G.Y.'s case, this position of neurophysiological comfort occurred toward the right and upper right. After holding the head in this position following the accident to enable easier fusion for many weeks and months, both the neck musculature and the vestibular mechanism in the inner ear had assumed a new orientation so that the new posture, tilted and turned to the upper right field, 'feels' to G.Y. like it is straight alignment. Demonstrating this mismatch to G.Y. in a wall mirror over a period of weeks allowed G.Y. to make vestibular, kinetic and visual impressions of head alignment to match. Obviously, the limitation of gaze discussed in Section 4.9 must be reduced in order for G.Y. to achieve single binocular vision to the right of midline with her head held straight. While viewing a target situated on G.Y.'s midlife, she tilted her head to the right as far as possible, attempting to touch her right ear to the right shoulder while maintaining single binocular vision. The same movement was repeated to the left side while maintaining single binocular vision. To offset the effects of possible suppression, red-green glasses can be used and were used early in G.Y's training program.

4.12. Unequal pupil size

Larger right eye pupil and sluggish reaction to light in right eye are both caused by the mechani-

cal injury to the right eye and the right orbit. The greater difficulty in accommodative facility in the right eye is thought to be related to this injury as well. Regularly assigned daily stimulation by light with a penlight into the right eye to enhance pupil reaction to light and reduce tonic pupil size brought about the changes noted under item 12 of Table 2. The initial 8 mm right eye pupil diameter under room light conditions was reduced to 5 mm over a 26-month period, thus causing a change in pupil tonus.

Many of the total changes brought about by the roughly 2-year therapy program could be measured by quantitative numerical values. In addition, the subjective general status of vision in patient/client G.Y. were tabulated qualitatively, as follows in Table 3.

5. Conclusions

The diagnosis, treatment and results of a visual therapy program of a woman with open head trauma resulting from an automobile accident has been described in this paper. The visual therapy program followed intense physical, occupational and speech therapy, as well as surgeries to head, ocular orbit and extra ocular muscles. The multiple visual dysfunctions present 2 years after the accident at the start of the training program were discussed and the 2-year course of the treatment program chronicled above. She was 54 years of age at completion of training and has been evaluated at 3-month intervals for a 12-month period following completion of the therapy program.

The improvements in best corrected distance and near acuity, steadiness of visual fixation, binocular alignment, improved function of lacrimal gland, pupil size and reaction to light, ranges and quality of fusion, reduction of head tilt/turn, reduction of diplopia and greatly extended field of gaze to the right and upper right, improvement of accommodative facility, binocular fusion ranges and stereopsis have all been maintained since the completion of the formal vision program 2 years previous.

The methods utilized in this therapy program are not novel and the results achieved are not extraordinary. What is unique are two factors: first, the length of time elapsed between the hea injury from the accident and the initiation of th vision therapy program (2 years), and second, th age of the patient in the therapy program (52–5 years of age) also expands our notion as to degre of neural plasticity in terms of almost complet recovery of a multiplicity of visual dysfunction produced in midlife.

While our personal experience with many such cases of visual and visual perceptual dysfunctio secondary to adult head trauma have shown tha spontaneous full recovery as the result of passag of time without treatment has rarely occurred What is needed for a final conclusion is a con trolled longitudinal study where measurements o visual and visual perceptual skills are carried ou periodically over a long period of time in a large number of adult TBI patients/clients, half o whom have been treated and half of whom have not. This single subject case study presents many clinical characteristics typical of post-head trauma and clearly illustrates the need to address a variety of visual functions as an integral part o treatment programs. The 2-year lapse of time after the trauma allows a generous opportunity for the spontaneous emergence of recovery of function. It is clear that this did not occur and that specific and carefully organized intervention techniques, even when applied to a middle-aged person, were effective in returning or restoring full visual function.

G.Y. is to be commended on the regularity of performance of her assigned therapy and the degree of cooperation and enthusiasm she maintained over the 2-year length of the program. At almost every therapy visit, G.Y. proclaimed, 'Things are getting better. All of this good work is paying off. I am not a quitter.'

The results achieved are a monument to this positive attitude. She is now engaged in a graduate level M.S./PhD university program in counselling. This previously avid reader, who became essentially a non-reader following her auto accident, is now succeeding in a heavy reading-writing-study program.

An additional important lesson to be learned from this case report is the essential multidisciplinary nature of the rehabilitation team. G.Y.

had 2 years of a varied regimen of therapies for speech, walking, balance and finger grasp which helped all of these functions. She was left, however, with monumental visual dysfunctions which did not allow her to read or carry out her previous job, nor to function in the lifestyle which she desired. Had this final step in the multidisciplinary team approach not been taken, she would still be facing a very altered, circumscribed and frustrating life.

References

[1] Cohen AH. Visual rehabilitation of a stroke patient. J Am Optom Assoc 1978;49:831–883.

[2] Cohen AH, Soden R. An optometric approach to the rehabilitation of the stroke patient. J Am Optom Assoc 1981;52:795–800.

[3] Jennett B, Teasdale G. Management of head injuries. Philadelphia, PA: F.A. Davis Co., 1981.

[4] Reitan RM, Wolfson D. Traumatic brain injury Vol I; Pathophysiology and neuropsychological evaluation. Tucson, AZ: Neuropsychology Press, 1986;43–59.

[5] Reitan RM, Wolfson D. Traumatic brain injury Vol.II; Pathophysiology and neuropsychological evaluation. Tuscon, AZ: Neuropsychology Press, 1986;35–69.

[6] Padula W. (ed.) A behavioral vision approach for persons with physical disabilities. Santa Ana, CA: Optometric Extension Program Foundation, 1988.

[7] Padula W, Argyris S et al. Visual evoked potentials (VEP) — Evaluating treatment for post-trauma vision syndrome (PTVS) in patients with traumatic brain injury (TBI). Brain Inj. 1994;8(2):125–133.

[8] Moore JC, Nelson CA. Closed Head Injury in Children and Adults. Clinician's View, Albuquerque, NM, 1995;48–58.

[9] Umphred DA. (ed.) Neurological Rehabilitation. In: Efferson L, ed. Disorders of vision and visual perceptual dysfunction, 3rd Ed., Chap. 27. St. Louis, MO: Mosby, 1995;769–801.

[10] Ludlam W. The Care of Amblyopia in the 4–10 Year Old Child. Proceedings of the National Academies of Practice Fourth National Health Policy Forum, ISBN No. 1-883848-00-8 National Academies of Practice, Washington, DC, April 24–27, 1992;50–57.

[11] Ludlam W. Strabismus. In: Borish, ed. Clinical Refraction, 3rd Ed., Chaps. 29–32. Chicago: Prof. Press, 1970;1175–1344.

[12] Warren M. A hierarchical model for evaluation and treatment of visual perceptual dysfunction in adult acquired brain injury: I. Am J Occup Ther 1993;47:42–54.

[13] Warren M. A hierarchical model for evaluation and treatment of visual perceptual dysfunction in adult acquired brain injury: II. Am J Occup Ther 1993;47:55–66.

[14] Schlageter K, Gray B, Hall KM, Shaw R, Sammet R. Incidence and treatment of visual dysfunction in traumatic brain injury. Brain Inj 1993;7:439–448.