

Vision profile of patients with mild brain injury – Part 1

Patients suffering from a traumatic brain injury (TBI) show many types of visual dysfunctions, including binocular, oculomotor, accommodative and visual field loss. This study evaluates the visual status of patients suffering a mild TBI.

Traumatic Brain Injury (TBI) patients manifest many types of visual dysfunction, including accommodative, binocular and oculomotor dysfunction, and visual field loss¹⁻¹⁶. These visual problems have a significant impact on everyday functioning and daily living activities, such as reading, driving, localising objects in space, and eye-hand co-ordination activities. Much of the literature regarding visual dysfunction in TBI concentrates on moderate-to-severe injuries. A patient with a mild TBI can also manifest significant functional deficits even in the absence of loss of consciousness at time of injury¹⁷. The current definition of mild TBI was developed by the Mild Traumatic Brain Injury Committee of the Head Injury Interdisciplinary Special Interest Group of the American Congress of Rehabilitation Medicine¹⁸. The diagnosis should be confirmed by a neurologist or neuropsychologist.

Table 1 Mean values for selected phoropter tests comparing the control sample with Morgan's values (standard deviation in parenthesis)

Distance findings	Controls	Morgan's values
Phoria	0.188 exo	1 exo (2)
BI break	9.000	7 (3)
BI recovery	4.500	4 (2)
BO break	16.750	19 (8)
BO recovery	8.750	10 (4)
Near findings	Controls	Morgan's values
Phoria	2.75 exo	3 exo (5)
BI break	20.500	21 (4)
BI recovery	13.063	13 (5)
BO break	16.688	21 (6)
BO recovery	8.625	11 (7)
NRA	+2.547	+2.00 (0.50)
PRA	-0.75	-2.37 (1.12)

BI = base in
 BO = base out
 NRA = Negative relative accommodation
 PRA = Positive relative accommodation

This committee has defined a patient with mild TBI as one who has had a traumatically induced physiological disruption of brain function.

It is manifested by at least one of the following:

- any period of loss of consciousness
- any loss of memory for events immediately before or after the accident
- any alteration in mental state at the time of the accident e.g. feeling dazed, disoriented or confused
- focal neurological deficit/s that may or may not be transient, but where the severity of the injury does not exceed the following:
 - loss of consciousness of approximately 30 minutes or less after 30 minutes, an initial Glasgow Coma Scale of 13 to 15
 - post-traumatic amnesia not greater than 24 hours

Whiplash or cervical strain can cause visual dysfunctions without a documented TBI¹⁹⁻²¹. Mild TBI encompasses a diffuse injury which can disrupt the overall speed, efficiency and integration of mental and central nervous system function.

Optometrists have historically treated functional and visual perceptual problems in children and adults^{2,12,22}. Therefore, it is appropriate for optometric services to be included in the rehabilitation of the TBI patient with visual problems^{1,2}.

The purpose of this study is to compare the visual profile of patients diagnosed as having mild TBI with a control group of non-TBI patients in a clinical population. The following functions were compared in the two matched groups (n=16, each group): symptoms, refractive status, near point of convergence, pursuits, ocular alignment by cover test, stereopsis, phorias, vergence ranges and relative accommodation. Additional diagnostic tests including ocular health assessment (pupillary function, internal and external ocular evaluation including dilated fundus examination and tonometry), visual acuity, visual electrodiagnostic testing, contrast sensitivity, visual fields and visual perceptual motor evaluation were also given to the TBI group. The data from these procedures are currently being analysed.

TBI subjects met all of the following criteria:

- a validated and confirmed history of mild TBI diagnosed by a neurologist or neuropsychologist
- visual acuity of 20/70 or better by Snellen acuity for each eye with best correction; monocular subjects were included
- free of any other unrelated ocular pathology
- free of any other unrelated systemic pathology

The non-TBI control group was matched by age and met all of the above criteria except for criteria one (mild TBI), as this group of patients must not have sustained TBI. The control group was comprised of individuals who presented for routine yearly optometric vision care at one of the authors' clinic (LFH).

Methods

Testing protocol for this study required a history, determination of refractive status and measurement of ocular motility, binocularity and accommodation.

History

An in-depth history was taken relating to TBI. In addition, a description of other professional and health care, general health, medications, symptomology and previous visual history were obtained.

Refractive status

Non-cycloplegic retinoscopy and subjective analysis were performed.

Ocular motility

Pursuit movements were qualitatively assessed with respect to accuracy, head movement involvement and restrictions to the extraocular muscles, using the SCCO pursuit evaluation technique.

Binocularity

The cover test was performed at 20 feet and at 16 inches in primary gaze (for noncomitant deviations all fields of gaze were assessed). Testing also included near point of convergence (NPC), horizontal and vertical phorias and vergence ranges at 20 feet and 16 inches (in a phoropter) and Randot stereopsis at 16 inches.

Accommodation

Positive and negative relative accommodation were measured in a phoropter.

Results

A total of 32 adults of both sexes participated in the study. The mean age for the 16 patients diagnosed with a mild TBI was 38.88 years, and the mean for the non-TBI controls was 38.93 years. No statistical difference in age between the groups was found to exist. There are published normative and expected findings for phorias, vergence ranges and relative accommodation for pre-presbyopic subjects²³.

Table 1 provides a comparison of the non-TBI control subjects' findings to the normative values reported by Morgan²³. All mean values for the control group fall within Morgan's expected ranges except for positive and negative relative accommodation. The accommodation findings would most likely be affected because of the presence of prebyopic patients in the study. Therefore, it appears that other than the accommodative findings, which are affected by age, the control group mean findings for phorometric testing are quite similar to Morgan's normative values.

A number of the binocular findings were not obtainable because of suppression or ocular discomfort. Only 10 of 16 of the TBI patients (63%) were able to respond to the near vergence testing (base-in, base-out break and recovery). Likewise, suppression did not permit measurement of the distance vergences on four members of the TBI group, resulting in a measurable response from 75% of the group. One patient was unable to be measured for the near cover test, near phoria, relative accommodation and the stereo acuity test. Subsequently, mean values were calculated in these instances based upon the number of individuals who were able to be measured for the respective test.

Seven of the TBI group findings were significantly different at the 0.05 level or better (t-test) based upon calculable mean values. These findings were the refractive error of each eye, the near point of convergence break and recovery, near cover test, stereopsis and base-in break at distance (**Table 2**).

There was an insignificant difference in refractive error between the two eyes of each member of either group, but there was a significant difference in the refractive error for the members of the two groups, as the TBI group was less myopic in each eye than the non-TBI control group.

Near point of convergence break and recovery for the TBI group was highly significant compared to the non-TBI control group. With both aspects of NPC, the findings of the TBI group were greatly receded from the non-TBI controls. Stereo acuity was highly significantly reduced in the TBI group when compared to the non-TBI control group, and the cover test at near revealed a significantly higher exo in the trauma group than in the control group.

The t-test method of analysis did not

take into account those patients who could not respond to the test, since these measurements were not available. Therefore, the Fisher Exact Test analysis (a type of which accounts for small samples) for each vergence finding was utilised to compare those patients in each group who did not fall within Morgan's normative values (± 1 standard deviation). The results are listed in **Table 3**.

The significant findings between the two groups using this analysis tool included distance base-in break and recovery, distance base-out recovery and near base-in break and recovery.

Pursuit behavior as evaluated by the SCCO technique was analysed statistically by the Fisher Exact Test, and it was found that eye movements were significantly poorer (0.001) in the TBI group than in the non-TBI control group (**Table 4**).

Symptom occurrence within the two groups was compared. A number of symptoms were significantly more prevalent in the TBI group than the non-TBI control group (**Table 4**).

Of the 13 symptoms which were recorded, nine were significantly more prevalent in the TBI group than in the non-TBI control group. These symptoms included - balance/co-ordination, blurred vision, diplopia, dizziness, headaches, photophobia, memory loss, nausea and reading problems.

Clearly, there are significant differences in the optometric findings of these two groups. Some of the significant findings could be more easily explained than others. The refractive error difference is likely due to the method of obtaining the two groups. The TBI group represents patients referred for evaluation due to reported visual symptomatology. The non-TBI control group represents patients obtaining routine vision care, most commonly for refractive conditions. Therefore, it is not surprising that the control group shows a more significant refractive error, as was found. These differences would take on more significance if it had been possible to obtain the previous refractive history for the TBI sample group.

The literature reports that binocular and oculomotor dysfunction are frequently associated with TBI¹⁻¹⁶. This TBI sample showed significant differences in NPC break and recovery, near point cover test,

Table 2
T-tests of mean values between normal and TBI samples

Findings	Controls	TBI	T-score	P-value	Sign
Cover near	0.875 exo	3.600 exo	2.567	0.0119	*
Dist BI BK	8.000	14.417	-2.356	0.037	*
Dist BI RE	4.500	3.833	0.980	0.340	
Dist BO BK	16.750	17.500	-0.233	0.819	
Dist BO RE	8.750	5.583	1.460	0.159	
Dist PHOR	0.188 exo	0.938 exo	-1.372	0.186	
Near PHOR	-2.750 exo	-4.467 exo	1.146	2.64	
NPC BK	1.5006	0.188	-4.019	0.001	*
NPC REC	3.0009	0.250	-3.727	0.002	*
Near BI BK	20.500	23.800	-1.789	0.95	
Near BI RE	13.063	7.600	2.032	0.069	
Near BO BK	16.688	21.100	-1.816	0.089	
Near BO RE	8.625	9.100	-0.230	0.814	
Pos ACC	0.750	1.000	-0.470	0.643	
Neg ACC	2.547	2.983	-1.878	0.071	
Ref OD	-2.188	-0.016	-2.967	0.006	*
Ref OS	-2.063	-0.094	-2.902	0.007	*
Stereo	40.000 sec	74.667 sec	-3.000	0.007	*
Vertical PHOR	0.094	0.344	-2.001	0.058	

BI = base-in **NPC** = near point of convergence
BO = base-out **ACC** = accommodation
BK = break **REF** = refraction
RE = recovery * = significant at 0.05 level
PHOR = phoria

Table 3
Fisher Exact Test analysis: vergence ranges of those subjects falling more than 1 standard deviation outside Morgan's normative values

	Controls	TBI	P	Sign
Dist BO BK	4	7	0.264	
Dist BO REC	4	11	0.013	*
Dist BI BK	1	13	0.001	*
Dist BI REC	1	6	0.033	*
Near BO BK	7	10	0.288	
Near BO REC	3	5	0.414	
Near BI BK	3	12	0.001	*
Near BI REC	0	11	0.001	*

BI = base in
BO = base out
BK = break
REC = recovery
* = significant at 0.05 level

Table 4
Fisher Exact Test of differences of incidences between normal and TBI samples

	Normal	TBI	P	Sign
Balance/co-ord	0	9	0.001	*
Blur	2	11	0.003	*
Clumsiness	0	3	0.226	
Diplopia	0	5	0.043	*
Dizziness	0	6	0.018	*
Focus	6	11	0.156	
Headache	3	10	0.029	*
Light sensitive	0	11	<0.001	*
Memory	0	6	0.018	*
Motion	0	2	0.484	*
Nausea	0	6	0.018	*
Ocular discomfort	4	3	1.000	
Reading problems	1	14	<0.001	*
Pursuits	2	14	0.001	*

* = significant at 0.05 level

stereoacuity and base-in break at distance. These results are in keeping with the literature, which reveals an exo trend, particularly at near.

The non-significant differences in the other vergence range tests (base-in near, base-out near distance) were unexpected. The t-test was not significant for these findings. It is important to note, however, that 25% of the experimental group suppressed at distance and 37% of the same group suppressed at near. The calculated mean values do not reflect those patients unable to complete the test and only show the patients with better fusion ability. Therefore, to include all patients in the analysis, a comparison was performed for each test of the percentage of patients in each group who fell within Morgan's normative values (Table 3). Analysis of these data demonstrated significant differences between the two groups when all patients were included. This result was true for all vergence findings except the distance base-out break and near base-out break and recovery. The analysis also supported the finding of a relationship between the TBI group and decreased visual function.

Other methods to evaluate fusion and vergence abilities should be considered with individuals diagnosed as TBI. These tests could include the following: fusional ranges with prism bar testing, fusional facility testing with prism flippers, and fixation disparity.

Several important observations were noted regarding the TBI group:

- some patients will become nauseous, causing discontinuation of the test. These subjects were included in the suppression group as they did not report diplopic images

- some patients did complete the vergence range test, but asked that the prism be moved at a slower rate, or asked the examiner to stop movement momentarily, due to ocular discomfort and nausea
- fusion tests require quick responses in noting changes in the target. The TBI patient often presents with diagnosed delays in processing skills. This delay could certainly have affected vergence test results by possibly inflating the range measurement because of slower patient response time. Therefore, fusion ranges could either have been lower, due to poor fusion abilities, or higher, due to delayed patient response.

The TBI group displayed significantly more symptoms than the non-TBI control group. Table 4 represents the frequency of distribution of non-TBI and TBI subjects for all symptoms investigated. It is apparent that, for each of the symptoms reported, except ocular discomfort, there are more complaints from members of the TBI group than from the control group, even though a statistical comparison of these frequencies did not reveal significance in all areas of investigation. A larger sample of subjects might show significance in a larger number of symptom categories.

Mild TBI patients show significant differences when compared to age-matched non-TBI patients in the following areas: symptoms, refractive status, near point of convergence break and recovery, near cover test, stereopsis, pursuit function, base-in break and recovery at distance and near and base-out recovery at distance. Such findings suggest that in-depth visual evaluation of this population is critical for documentation purposes as well as for the determination of possible treatment regimes. The term 'mild TBI' is very misleading, and does not necessarily translate to 'mild functional loss', as these injuries can have a devastating impact on performance.

Longitudinal studies which track improvement in standard measures of recovery from TBI should be related to accompanying changes in visual measurements and visual symptoms. Therapeutic regimens should be documented to ascertain how rehabilitative vision therapy impacts the recovery of function in this special population.

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