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Neuropsychological Correlates of Diplopia (Double Vision) in Motorists with Traumatic Brain Injury

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Abstract

***Background:** The symptom of double vision, known in ophthalmology as diplopia, is observed with various neurological conditions such as in multiple sclerosis, Parkinson's disease, and the post-concussion syndrome. Our study examines the correlates of diplopia in survivors of high impact motor vehicle accidents (MVAs).*

***Method:** Data on diplopia were available for 65 patients injured in MVAs (mean age of 38.1 years, SD=13.1; 24 men, 41 women). All patients were assessed using the Rivermead Post-Concussion Symptoms Questionnaire, Immediate Concussion Symptoms scale, the Post-MVA Neurological Symptoms (PMNS) scale, Insomnia Severity Index, as well as selected items from the Brief Pain Inventory (ratings of worst, least, and of average pain) and from the Whiplash Disability Questionnaire (ratings of depression, anger, and anxiety).*

***Results:** Diplopia was reported by 27.7% of the patients. Ratings of diplopia correlated at a significant level ($p<.05$, 2-tailed) with the total Rivermead post-concussive score ($r=.46$) after the item "double vision" was removed from the Rivermead's total score, and also with the total score on the PMNS scale ($r=.35$). Diplopia also correlated significantly with Rivermead's post-concussive symptoms of blurred vision, oversensitivity to bright lights (photosensitivity), restlessness, dizziness, nausea, and problems with slow speed of thinking (the rs ranged from .30 to .57). With respect to individual items of the PMNS scale, diplopia correlated significantly to impaired balance, hand tremor, reduced control over hand or arm, and to some loss of bladder control (the rs ranged from .30 to .41).*

***Discussion and Conclusions:** Diplopia was reported by 27.7% of survivors of high impact MVAs and was correlated with various other post-concussive symptoms, especially blurred vision, photosensitivity, and impaired balance.*

Introduction

In ophthalmology, the symptom of double vision is associated with multiple aetiologies including acute alcohol intoxication (Peragallo et al., 2013), neurological diseases such as multiple sclerosis (Zeigeboim et al., 2006) and Parkinson's disease (Tanveer et al., 2018, Visser et al., 2019, Mao et al., 2014), and with infections, including coronavirus disease (Luís et al, 2020). Diplopia may also result from cerebral concussion: it is included as an item in the widely used Rivermead measure of the post-concussion syndrome (Eyres et al. 2005).

In normal elderly persons, double vision can also occur temporarily with extreme fatigue caused by

sleep deprivation or severe physical illness: the person may notice seeing, at times for brief moments, 2 wall clocks next to each other, instead of the usual only one. The image corrects to only one clock when straining the eyes. Bartiss (2019) suggested that old age may represent an important factor in prevalence of diplopia.

Oculomotor symptoms, their assessment, and their treatment have been more intensively investigated and studied in the recent decade. They occur in perhaps about 30 % of motorists who sustained cerebral concussions in high impact motor vehicle accidents (MVAs). Treatments of oculomotor symptoms are now provided by some specialized neurophthalmologists.

A 15 item questionnaire of oculomotor symptoms has recently been published (Cernovsky, et al., 2020) for the use by physicians or psychologists, to serve as a screening instrument that could be administered to patients in the waiting room by administrative staff and then, reviewed by the health professional. The screening questionnaire provides a preliminary assessment of oculomotor symptoms as a basis for potential referrals to neurophthalmologists for more extensive specialized assessments and for therapy.

The present study focuses on the symptom of diplopia and examines its frequency and correlates in drivers or passengers who were injured in high impact MVAs.

Method

De-identified archival data from an assessment clinic were available on 65 patients injured in high impact MVAs. The group consisted of 24 men and 41 women, with a mean age of 38.1 years, SD=13.1, and an age range of 15 to 70 years. Their accident occurred, on average, 51.0 weeks earlier (SD=34.0), range 7 to 146 weeks. All still experienced intense post-MVA symptoms that included persistent pain, insomnia related to pain, post-concussive and whiplash symptoms, PTSD symptoms, and some post-accident depression and anxiety.

In their MVAs, 43 were drivers, 9 were passengers, one drove a motorcycle, and 12 were pedestrians hit by a car. All 65 patients were diagnosed with the post-concussion syndrome as the direct result of their MVA.

The data used in the present study included the patients' scores on Rivermead Post-Concussion Symptoms Questionnaire(Eyres et al, 2005), the Immediate Concussion Symptoms scale (retrospective ratings of 6 concussion symptoms as in the immediate aftermath of the accident, see Cernovsky et al., 2018), and the Post-MVA Neurological Symptoms scale (PMNS) scale (Cernovsky et al., 2019). The data also included the patients' scores on Items 3, 4, and 5 of the Brief Pain Inventory (Cleeland and Ryan, 1994), i.e., the ratings of worst pain, least pain, and of average pain on a scale from 0 ("no pain") to 10 ("pain as bad as you can imagine").

The data also included total scores on the Insomnia Severity Index (Morin et al., 2011) as well as the patients' self-ratings on Items 10 to 12 of the Whiplash Disability Questionnaire (Pinfold et al., 2004), i.e., ratings of depression, anger, and of anxiety via scales from 0 ("not at all") to 10 ("always").

Results

The Rivermead scale of the post-concussion syndrome includes, as one of the items, the patient's self-ratings of diplopia on a scale ranging from 0=no pathological level, 1=only in the past, not at present, 2=mild, 3=moderate, to 4=severe. Severe diplopia was reported by only 2 patients (3.1%), moderate by 5 (7.7%), mild to moderate by one patient (1.5%), mild by 10 (15.4%), no diplopia at present (only in the past) by 8 patients (12.3%), and no diplopia (past or present) by 39 patients (60.0%).

Correlations of Diplopia to other Items of Rivermead Scale

The total score on the Rivermead scale of our patients ranged from 22 to 63 points, with the average of 45.3 points (SD=9.9).

Double vision is, as already mentioned, one of the items of the Rivermead scale. The correlation of diplopia to the sum of remaining items of the Rivermead scale was .46, $p<.001$, i.e., indicating relationship of moderate strength: patients with more severe post-concussion syndrome were more likely to report diplopia.

The correlations of diplopia to the individual items of Rivermead scale are listed in Table 1.

Table1. *Correlations of Rivermead post-concussive symptoms to diplopia (N=65)*

Rivermead items:	Pearson rs:	p value (2-tailed):
1. Headaches	.25	.043
2. Feelings of Dizziness	.36	.003
3. Nausea and/or Vomiting	.30	.016
4. Noise Sensitivity, easily upset by loud noise	.15	.249, not significant
5. Sleep Disturbance	.18	.155, not significant
6. Fatigue, tiring more easily	.10	.429, not significant
7. Being Irritable, easily angered	-.02	.850, not significant
8. Feeling Depressed or Tearful	.12	.359, not significant
9. Feeling Frustrated or Impatient	.10	.427, not significant
10. Forgetfulness, poor memory	.28	.023
11. Poor Concentration	.25	.045
12. Taking Longer to Think	.30	.016
13. Blurred Vision	.57	<.001
14. Light Sensitivity, easily upset by bright light	.43	<.001
15. Double Vision, i.e., diplopia	n/a	n/a
16. Restlessness	.37	.003

Legend: n/a = not applicable

The correlations are only of mild to moderate size. The most salient ones (those of .30 or above) are those of diplopia to blurred vision, oversensitivity to bright lights (photosensitivity), restlessness, dizziness, nausea, and problems with slow speed of thinking.

No significant correlations (p values were >.05, 2-tailed) were observed to retrospective recall of immediate symptoms of cerebral concussion as they occurred on the day of the MVA, i.e., to symptoms listed in the ICS scale (feeling stunned, dazed, dizzy, confused, and disoriented, and loss of consciousness).

Correlations of Diplopia to the PMNS Scale

Diplopia correlated significantly but at a weak level with the total score on the Post-MVA Neurological Symptoms (PMNS) scale (r=35).

Significant correlations were found also between diplopia and some individual items of the PMNS scale, see Table 2.

Table2. *Correlations of diplopia to items of the Post-MVA Neurological Symptoms (PMNS) scale (N=65)*

PMNS items:	Pearson rs:	p value (2-tailed):
1. Impaired balance	.41	<.001
2. Excessive hand tremor	.38	.002
3. Instances of reduced control over leg muscles	.13	.286, not significant
4. Instances of reduced control over hand or arm	.31	.012
5. Tingling in the arm, or hand, or leg	.00	.995, not significant
6. Numbness in the arm, or hand, or leg	.13	.304, not significant
7. Reduced feeling in the arm, or hand, or leg	.13	.316, not significant
8. Some loss of bladder control	.30	.017
9. Some loss of bowel control	.20	.115, not significant
10. Stutter	.27	.031
11. Word finding difficulty	.18	.145, not significant
12. Difficulty articulating words	.12	.329, not significant
13. Tinnitus	.26	.040

Legend: n/a = not applicable

The most salient of these correlations of diplopia (those of .30 or above) are to impaired balance, hand tremor, reduced control over hand or arm, and to loss of bladder control.

Correlations of Diplopia to Insomnia Score, Ratings of Pain, and Ratings of Depression, Anger, and Anxiety

No significant correlations were found to the patients' ratings, on the Brief Pain Inventory, of the worst, least, and average pain.

Similarly, no significant correlations were found to the total score on the Insomnia Severity Index, and to the patients' self-rating of depression, anger, and anxiety.

Correlations of Diplopia to Age and Gender

In this group of injured motorists, no significant correlations were observed to age or gender.

Discussion and Conclusions

Blurry or double vision (diplopia) is a common complaint after a concussion and may result from damage to the muscles and/or nerves around the eyes or to the central nervous system in high speed vehicular collisions. In our study of 65 patients assessed following motor vehicle accidents, diplopia was reported by 27.5 percent.

Diplopia was usually present only in a mild or moderate form, and usually only in a sporadic rather than constant fashion. In this group of patients, it rarely hindered daily activities such as grasping small objects, watching the TV, or walking.

In this group of MVA patients, diplopia was correlated with other neuropsychological symptoms such blurred vision, oversensitivity to bright lights (photosensitivity), impaired balance, hand tremor, restlessness, or dizziness. This underscores the importance of seeking specialized opthalmological services in the overall management of the post concussive syndrome.

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