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# Disorders of Accommodative Convergence and Accommodation (AC/A) Relations at Traumatic Brain Injury

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## ABSTRACT

**Introduction:** Accommodative Convergence/Accommodation (AC/A) ratio is constant at one and the same person in the course of life, i.e. the same ratio accommodative convergence monitor any change in accommodation measured in diopters. Such a perfect relationship is possible if there are no refractive anomalies in both eyes and oculomotor imbalance of eye muscles. **Material and methods:** We are examined 50 patients with close brain injury, and patients which had problems with near vision, accommodation and convergence were reduced, with loss motor fusion, and preserved stereopsis vision, and showed us, that disturbances are clear motor and followed with incapable of patient to hold of superposition view to watching object. **Results:** The difference in average proximity distance vision and reading time with no fatigue after 6 months a statistically significant, the value of t-test,  $t = 1873$  for  $p < 0.01$ ,  $r = 0.718$ . The value of convergent fusion 6 months after treatment in 30% of the patients was from 0 to 16 Pd, S. D. = 18.6, and  $\chi^2 = 7.22$ . In 18% of the patients was from 0 to 10 Pd, S. D. = 17.61, and  $\chi^2 = 5.41$ , at 20% of patients 0 to 22 Pd, SD = 14.18,  $\chi^2 = 6.84$ , in 16% of patients 0 to 4 Pd, SD = 16.41,  $\chi^2$  t-test = 5.13 and the remaining 16% of patients the value of convergent fusion is about 1 PD, S. D. = 15.01,  $\chi^2$  t-test = 9.41, after 6 months of treatment, there is considerable significance  $p < 0.01$ , t-test 0.914, correlation coefficient  $r = 0.881$ . **Conclusion:** Disturbances of AC/A ratio should be evaluated only with regard to all symptoms and is only possible by proper rating interference in reading.

**Key words:** disorders of AC / A, traumatic brain injury, motor fusion.

## 1. INTRODUCTION

Accommodative Convergence/Accommodation (AC/A) ratio is constant at one and the same person in the course of life, i.e. the same ratio accommodative convergence monitor any change in accommodation measured in diopters. Such a perfect relationship is possible if there are no refractive anomalies in both eyes and oculomotor imbalance of eye muscles. People with normal binocular vision have synergism between accommodation and convergence that will remain throughout your life, but there may be abnormal relations between accommodation and convergence (Donders 1864), which were then connected only with refractive error. Today we know that these abnormal relationships can be complex and brain injuries, because traumatic brain injury of the vibration waves through the impact force can no visible external injuries caused by a variety of transient cerebral dysfunction. Accommodation represents the ability of the eye that may be willing to adjust the distance of objects by increasing the strength and fracture of light through the lens, so that the

lens resulting from the contraction of m. ciliar, represents a convergence of eye position for viewing in the vicinity, with directions for viewing do not go looking in parallel at a distance, but cut in front of the eyes. Refraction optical system depending on the distance from the fixed objects is constantly changing. Accommodation reflex speed is 0.5–1.5 sec. One of the most important stimulus of accommodation is a blurred image of an object on the retina of the eye, and another bitemporal disparity image on retina of the eye that occurs when the convergence of light rays that fall on the retina of the eye is not sufficient (1,2,3,4,5).

## 2. GOAL

The goal is to establish correlation disorders AC/A relationship in traumatic brain injury.

## 3. MATERIALS AND METHODS

The study was conducted as a prospective, clinical, controlled, descriptive study of a period of four years

at the Department of Ophthalmology, Clinical Centre of Sarajevo University. The study included 50 patients, aged from 15 to 40 years, with traumatic brain injuries and their main difficulty was the blurred vision at near. From the study were excluded patients younger than 15 years because of the difficulty to cope in certain tests and older than 40 years for any wrong interpretation, for the occurrence of presbyopia. Patients with neurological syndromes, persons with previous motility disorders and refractive anomalies greater than 1 Dptr are also excluded from the study. The control group consists of patients of the same age with the same difficulties that had a traumatic brain injury. In all patients who were included in the study according to previously established criteria, we examined the following: determination of visual acuity, monocular and binocular, skiascopy, autorefractometry, examination of the anterior eye segment, a review of the ocular posterior segment, motility and oculomotor balance, Cover-Uncover tests, accommodation and convergence, measuring AC/A ratio by the gradient several times due to differences between the estimates of deviation eyes on a given distance using Maddox glass in front of one eye and a prism to correct the other eye before and after putting the convex and concave lenses, which causes a change in their accommodation (positive or negative) and the resultant change in the corresponding positive or negative convergence test Hess–Lancaster, Bielschowski test, examination of fusion with prisms, an examination of stereo vision, neurological examination, CT of the brain after injury and statistical analysis.

Method	Quantitative measures	Formula	Mean Rank	Abnormal relationship
Gradient	<u>Accommodative convergence accommodation</u>	$\frac{\Delta_1 - \Delta_2}{D}$	$2.8 \Delta / D$	$> 4.6 \Delta / D$

**Table 1.** Clinical method for measurement of accommodative convergence of the gradient method.

#### 4. RESULTS

Among the respondents were 40 (80%) male and 10 (20%) female patients. The largest percentage of participation by sex and age structure is patients aged 15 to 20 years old (40%). In examining the visual abilities of subjects at a distance after fixation in the vicinity of prior treatment for binocular vision (VOU = 0.5–0.6) has a percentage of 54% or 27 patients. Size angle of exophoria measured with prism diopters before treatment (6–8 Pd) was observed in 52% of our respondents 4 to 6 PD in 30% and 2 to 4 Pd in 18% of our respondents. Size of accommodation in 60% was 3.3 D, in 22% D 4.0 and in 18% 5.0 D.

The nearest point of convergence in cm	Prism base temporal	Prism base nasal	Number of patients	%
26	0 Pd	6 Pd	30	60 %
15	1 Pd	4 Pd	11	22 %
9	2 Pd	2 Pd	9	18 %
		Total	50	100 %

**Table 2.** The strength of convergence before treatment.

AC/A ratio	Number of patients	%	Size angle of exophoria
Normal (2.5-2.8 Pd)	9	18 %	2-4 Pd
Decreased (0.8-1.2 Pd)	15	30 %	4-6 Pd
Abnormal (0-0.5 Pd)	26	52 %	6-8 Pd
Total	50	100 %	

**Table 3.** Measurement of AC / A ratio of the gradient method.

Sizes of convergent fusion	Number of patients	%	S. D.	Hi <sup>2</sup> t-test
To 2 Pd	25	50 %	14. 61	9. 61
Instability between 0-6 Pd	15	30 %	18. 6	11. 22
To 12 Pd	10	20 %	14. 18	6. 84
Total	50	100 %	17. 11	9. 41

**Table 4.** Mean values of convergent fusion before treatment.

Size of convergent fusion	Number of patients	%	S. D.	Hi <sup>2</sup> t-test
Stability 0-10 Pd	9		17.61	5.41
Stability 0-4 Pd	8	50 %	16.41	5.13
About 1 Pd	8		15.01	5.18
0 – 16 Pd	15	30 %	18.6	7.22
0 – 22 Pd	10	20 %	14.18	6.84
Total	50	100 %	21.44	6.81

**Table 5.** The value of convergent fusion 6 months after treatment prisms.

Distance in cm	Number of patients	%	Time	S. D.	X <sup>2</sup> t-test
J 1 at distance of 30 cm	17	34 %	30"	32. 46	18. 041
	10	20 %	40"	41. 14	20. 22
J 1 at distance of 25 cm	10	20 %	30"	24. 17	16. 41
	13	26 %	25"	21. 18	14. 14
Total	50	100 %	31"	36. 18	19. 44

**Table 6.** Proximity and sight reading time without fatigue 6 months after treatment prisms.

#### 5. DISCUSSION

Duration of reading is defined by the maximum time for which the patient can read constant before it comes to blurred vision and diplopia. Based on the obtained data we believe that we get good results proximity of vision after treatment of 6 months, and extended reading time without fatigue at 20% of patients who read J 1 at a distance of 25 cm for 30" where the standard deviation shows the values 24.17,  $\chi^2 = 16.41$ . Average result we obtained: in 34% of patients J 1 is read at a distance of 30 cm for 30" where SD = 32.47,  $\chi^2 = 18.041$ , in 26% of patients that J 1 is read at a distance of 25 cm in length from 25" where SD= 21.18,  $\chi^2 = 14.14$ . Unstable results in 20% of patients J 1 read at a distance of 30 cm in length from 40" with low value of convergent fusion about 1 Pd exophoria in 8 patients and 8 patients with a value of convergent fusion from 0 to 4 Pd in exophoria.

The difference in average proximity distance vision and reading time with no fatigue after 6 months a statistically significant, the value of t-test,  $t=1873$  for  $p < 0.01$ ,  $r = 0.718$ . These were patients who had astenoscopic inter-

ference and showed slight disparity image that has been fused by the patients fused after home exercises. The value of convergent fusion 6 months after treatment in 30% of the patients was from 0 to 16 Pd, SD = 18.6, and  $\chi^2 = 7.22$ . In 18% of the patients was from 0 to 10 Pd, SD = 17.61, and  $\chi^2 = 5.41$ , at 20% of patients 0 to 22 Pd, SD = 14.18,  $\chi^2 = 6.84$ , in 16% of patients 0 to 4 Pd, SD = 16.41,  $\chi^2 = 5.13$  and the remaining 16% of patients the value of convergent fusion is about 1 PD, SD = 15.01,  $\chi^2 = 5.18$ . All patients showed significant improvement in near vision compared to the value of convergent fusion before treatment where  $\chi^2 = 9.41$ , after 6 months of treatment, there is considerable significance  $p < 0.01$ ,  $t$ -test = 9.14, correlation coefficient  $r = 0.881$ .

Comparing our criteria with other authors, we see that the authors (6,7) suggest that 50% of patients with traumatic brain injuries show a systematic change in the visual sense disturbances of central vision in viewing proximity without disturbances oculomotor balance. In the second case in a sample of 314 patients, 70% of them had parafoveal eliminated from  $-5^\circ$  or less, and 50–70% of these patients objectively showed chronic deficits in reading and visual examination of remote vision after fixation on the near (8, 9). In our sample exophoria the vicinity were all patients and was  $-4^\circ$  and less, which is 100%, as an excess of convergence and microexotropia we do not find in our sample, which is confirmed by other authors (10, 11). Persuasive difficulties in reading were found in our sample with 82% of patients, while 18% of patients were uncertain whether the answers to questions. On eye examination, eight (25%) patients were diagnosed with convergence insufficiency and seven (23%) had accommodative insufficiency. The average NPC (near point of convergence) in patients diagnosed with convergence insufficiency was  $29.2 \pm 24.0$  cm (normal range:  $2.5 \pm 2.5$  cm). Of the patients who were unemployed ( $n = 4$ ), 75 percent were diagnosed with accommodative insufficiency and/or convergence insufficiency, compared with only 33 percent of employed patients ( $n = 27$ ). All patients with accommodative insufficiency were given reading and computer glasses (12).

Some of the authors (13, 14), this explains the difficulty in reading non-permanent fixation that causes nystagmus, which can impair the spatial sense, especially in fine detail, especially if fixation insufficient time had to identify small opto tips or written characters. These authors also found a high rate of visual impairment and near-work related deficiencies in their patient population despite relatively normal visual acuity and normal visual fields. Later studies report that veterans with blast-induced TBI with auditory deficits are likely to also have visual disturbances and vice versa (15).

Insufficient of motor and sensory fusion are rare but are extremely common disorder of motor fusion in patients with traumatic brain injury (16, 17, 18), which we found in our survey, the mean convergent fusion before treatment in 50% of patients up to 2 Pd, with SD = 14.61 and  $\chi^2 = 9.61$ , while the unstable values in 30% of patients 0 to 6 Pd with S. D = 18.6 and  $\chi^2 = 11.22$ , which is insufficient for a longer view of the proximity. Clinical experience has suggested that motor fusion and approaching the eye move-

ments are important for the long term operation in the vicinity (19). Based on recent literature reports, evidence is mounting that symptoms associated with combat-related post concussion disorder in service members can persist much longer than expected, and extended monitoring may be necessary in patients with chronic medical problems after TBI (20,21,22).

## 6. CONCLUSION

All patients with traumatic brain injuries have been reported problems when viewing proximity and rapid fatigue, and have not had similar complaints. After careful and repeated examination may be diagnosis of AC/A paresis of the lack of motor fusion, which is very difficult clinical entity. Disturbances of AC/A ratio should be evaluated only with regard to all symptoms and is only possible by proper rating interference in reading.

## CONFLICT OF INTEREST: NONE DECLARED.

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