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THE IMPORTANCE OF OPTICAL COHERENCE TOMOGRAPHY IN THE DIAGNOSIS OF RETINAL AND OPTIC NERVE INJURIES

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A B S T R A C T

Relevance. The article is devoted to the issue of utility and possibilities of optical coherence tomography (OCT) in closed globe injury (CGI) in order to objectively assess the state of the optic nerve disc (OND) and the peripapillary of retinal nerve fibers layer (RNFL) of the traumatized eye.

Purpose of the study: to determine the diagnostic capabilities of OCT in patients with closed globe injury (CGI) and traumatic optic neuropathy (TON) caused by contusion.

Materials and Methods. A study of 30 patients, including 20 men, and 10 women aged 20 to 45 years with transparent optic media in the early period after trauma was conducted in the multispecialty clinic of Tashkent Medical Academy in the departments of emergency traumatology and neurosurgery. The control group consisted of 30 healthy individuals of similar sex and age.

Results of the study. OCT allows to determine the thickness of RNFL and the degree of fiber damage in the retina and optic nerve due to the traumatic process at the earliest stage after the trauma when other traditional ophthalmologic examinations turn out to be uninformative.

As a result of the study, a significant increase in macular volume, the size of OND, and the thickness of peripapillary fibers of RNFL was found on optical coherence tomography in patients with CGI compared to the control group

Conclusion. Our study has shown that OCT can be used for objective assessment and diagnostics of retinal and optic nerve damage in CGI.

K E Y W O R D S

Optical coherence tomography; closed eye trauma; optic nerve; traumatic optic neuropathy; retinal nerve fiber layer; macula.

Introduction

Eye injuries are among the main causes of blindness and loss of the eye as an organ. Closed globe injury (CGI) is an injury of the visual organ characterized by the presence of intraocular and/or corneal-scleral injuries without penetrating/perforating of the fibrous membrane of the eye.

Eye contusions, being the most frequent manifestation of CGI occupy one of the first places in the general structure of traumatic injuries of the visual organ. Recently there has been an increase in the number of patients with severe contusional lesions. Frequent occurrence mainly in young people of working age and the possibility of complications development, representing a serious threat to vision, determine the medical and social significance of eye contusion injuries. The analysis of the state of the problem has shown that contusion occupies the leading place among domestic traumas and is one of the main causes leading to disability in 17.9-33% of cases [1,6,8].

Ophthalmoscopic visualization of the optic nerve in trauma is difficult and limited to its intraocular part. Due to these instrumental diagnostic methods allowing to localize and evaluate pathognomonic morphofunctional changes in this ophthalmopathology come to the forefront. In the last decade, new technologies have been developed and introduced into ophthalmic practice, which provide quantitative and qualitative assessment of morphofunctional features of the optic nerve disc (OND), retinal nerve fiber layer (RNFL), as well as inner and outer layers of the central retinal zone [8, 9].

Thereby the search for new noninvasive methods of visualization of changes in the OND and peripapillary retina in traumatic eye lesions is relevant. Optical coherence tomography (OCT) is one of such promising methods in the diagnostics and assessment of the optic nerve disc (OND) and peripapillary retinal nerve fiber layer (PRNFL) condition in the development of traumatic optic neuropathy (TON).

Purpose of the study

To determine the diagnostic capabilities of OCT in patients with closed globe injury (CGI) and traumatic optic neuropathy (TON) due to contusion.

Materials and methods

Thirty patients with concussive eye trauma and transparent optic media were examined in the emergency traumatology and neurosurgery departments of the multidisciplinary clinic of the Tashkent Medical Academy. The average age of the patients was 42,9±15,8 years. OCT examinations of the traumatized and paired healthy eye were performed 2,25±2,43 days after eye contusion on Huvitz optical coherence tomograph (HOCT- 1F/1), South Korea).

Technical characteristics of the device: speed - 26000 A-scans per second; 256 to 16384 A-scans are used to construct a B-scan; longitudinal optical resolution in tissue 5 μm; transverse image resolution from 8 μm; beam diameter 15 μm; scanning depth up to 2,3 mm; scanning laser beam with a wavelength of 840 nm. Program version 4.0 was used. OND and RNFL were analyzed at a calculated diameter of 3.45 mm around the center of the disc.

The reliability of the differences between the results of measurements of the traumatized and paired healthy eyes was evaluated by the Student's t-criterion (the differences were reliable at $p < 0,05$).

The criteria for exclusion of patients from the study were as follows: the presence of eye pathology affecting the function and structure of the optic nerve, the presence of severe concomitant somatic

pathology (clinically significant pathology of cardiovascular system, respiratory system, gastrointestinal tract), age younger than 18 years.

The control group consisted of healthy individuals of similar sex and age, including 30 people, of whom 20 were men, and 10 women aged 20 to 45 years. The group of patients and the control group were homogeneous in age (Kolmogorov-Smirnov criterion, p>0).

All patients underwent complex neuro-ophthalmological examination, which included, along with traditional ophthalmological examination (visometry, perimetry, ophthalmoscopy), the following methods: OCT, computerized perimetry of central visual fields (according to Armaly program, Humhprey 24/2), as well as neurological examination, magnetic resonance imaging (MRI). OCT was performed on a Huvitz device (HOCT- 1F/1,South Korea).The mean central fossa thickness (μm) and macular volume (mm3) of the retina were calculated for each measurement in automatic mode using the research protocol "Retinal thickness / Volume Tabular" included in the software package of the tomograph. The scanning protocol used to assess the macular area was "Raster Lines" and "RNFL thickness (3.4 mm)", according to which the thickness of the RNFL was determined on a 3.4 mm diameter circle centered manually by the operator relative to the optic disc. The results were processed using the "RNFL thickness average" analysis protocol. Both protocols are standard for RNFL evaluation and allow statistical comparison of the results with an extensive normative database. The used analysis protocol defines a large number of quantitative parameters characterizing the RNFL thickness in each of 12 sectors, 4 quadrants, and the average for the whole circumference, as well as several calculated parameters. Statistical indicators of the existing normative base which are introduced for this instrument are not standardized. Thus for reliability of own normative values, a group of healthy individuals, which included 30 people (20 men, and 10 women aged from 20 to 45 years), was additionally examined. We compared both with our own standards and with the standard base of the Huvitz device (HOCT- 1F/1, South Korea).

In the process of the conducted examination, certain facts were confirmed: the lesion of the posterior segment of the eye at CGI causes edema of the optic nerve disc (OND) and peripapillary retina [1], which indicates the involvement of the optic nerve in the post contusion process and the development of traumatic optic neuropathy (TON). Until relatively recently, the fact of edema of the OND and peripapillary retina could be detected only with the help of widely available ophthalmoscopy. Thus, in ocular contusion, W. Paul and K. Grud detected edema in 25% of cases of OND [2], while in the studies of V.V. Kashnikov ophthalmoscopically detectable edema of the OND in eye contusion was noted in 37.2% of patients with transparent optical media [3].

Optical coherence tomography of the macula can be recommended in case of hemorrhages, edema, and ruptures of the macular area; it is performed both when establishing the diagnosis and for control of the treatment process and prognosis of the state of visual functions.

Results of the study

All patients of the main group underwent MRI of the brain. MR signs of closed craniocerebral trauma of the brain were detected in 58% of cases. As a result of the study it was found that the severity and expressiveness of the traumatic brain injury has no direct correlation and does not affect the thickness of the entire retinal layer in the macular area, but depends on the direct trauma to the eyeball and orbital contents. The results of OCT of the OND and RNFL and their statistical analysis are summarized in

Table 1. The obtained data show that in the early period after trauma in the contused eye compared to the healthy eye there is edema of the OND, expressed in the increase of its volume, an increase of the volume and area of the neuroretinal rim, as well as in the decrease of the volume and area of excavation. Along with this, there is peripapillary retinal edema (increased thickness of the RNFL in the peripapillary zone).

Ophthalmoscopically, pallor of the temporal half of the optic disc was noted, which may be related to the initially smaller thickness of the RNFL in the temporal quadrant. This symptom was diagnosed in 26 people (41 eyes - 35.3%), 15 of them in both eyes.

Literature analysis showed that there are few publications on the application of classical OCT in eye traumas. Thus, R. Vessani et al. [10] described a single case of peripapillary retinal edema in early eye trauma, which was then replaced by its thinning.

Table 1 Characteristics of the OND and RNFL according to OCT data in the patients of the main group (n=30)

Morphometric parameters of OND and RNFL	Injured eye (M ± m)	A healthy paired eye (M ± m)	P value
Volume of neuroretinal rim, mm3	0,22 ± 0,08	0,17 ± 0,05	0,03
Volume of OND, mm3	0,42 ± 0,13	0,3 ± 0,13	0,007
Excavation volume, mm3	0,07 ± 0,06	0,13 ± 0,12	0,06
Average thickness of RNFL, nm	110,22 ± 12,32	105,94 ± 9,4	0,007
Disk area, mm 2	2,1 ± 0,43	1,88 ± 0,37	0,03
Area of neuroretinal rim, mm2	1,63 ± 0,33	1,24 ± 0,29	0,03
Excavation area, mm 2	1,63 ± 0,33	0,64 ± 0,42	0,03

S. Rumelt et al. [11] described a single case of edema of the OND and peripapillary retina in closed-eye trauma. F.A. Medeiros et al. [5] showed on OCT a decrease in the thickness of the peripapillary RNFL after the development of indirect TON. W. Shi et al. [12] using OCT noted that the thickness of the peripapillary RNFL is slightly increased within 2 weeks after the injury, and after 4 weeks it decreases.

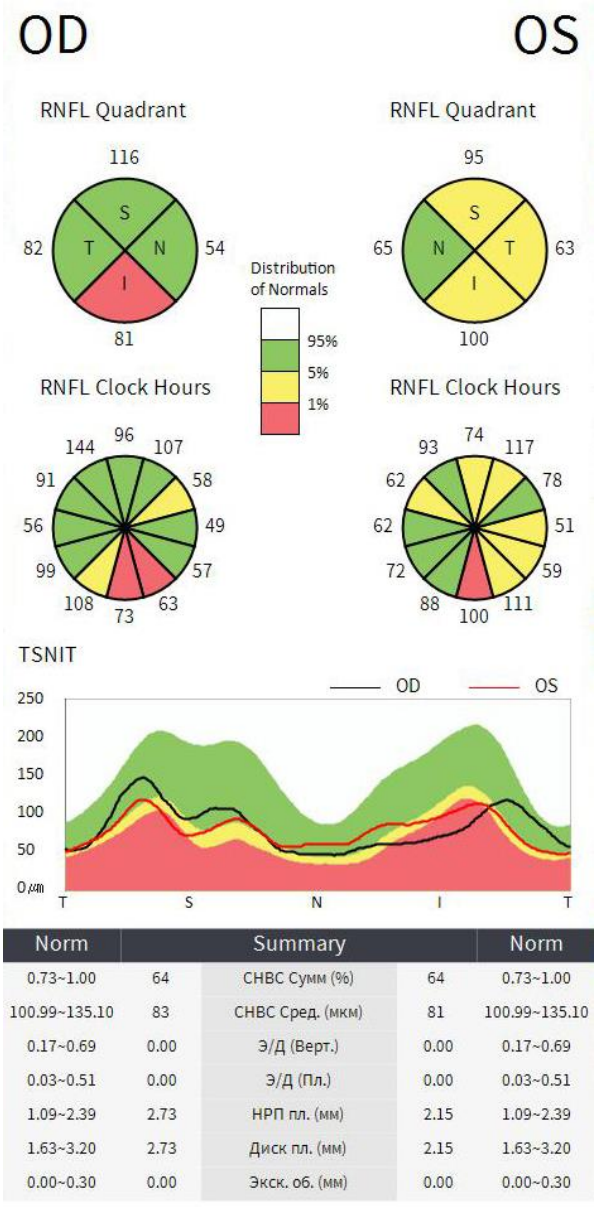
When analyzing the peripheral visual field of patients with CGI, performed according to the standard technique on white color in 76 % of cases the indices remained within the age norm, while in 63 % of cases narrowing of visual fields on colors was noted. At the same time, 36,6 % of subjects (11 people) had sufficiently high visual acuity (from 1,0 to 0,8 with correction). The study of central visual fields using the computer program Humhprey 24/2 proved to be a more sensitive technique, which revealed a decrease of sensitivity in central and paracentral sections (average deviation from – 0,8 to – 18,0 DB).

As an example, Figures 1 and 2 reflect the variants of analyzing the thickness of the RNFL around the optic nerve in a patient with CGI of the traumatized and healthy eye.

Figure 1 shows RNFL thickness data in microns for 12 sectors and 4 quadrants and the average thickness over the entire circumference of the right eye.

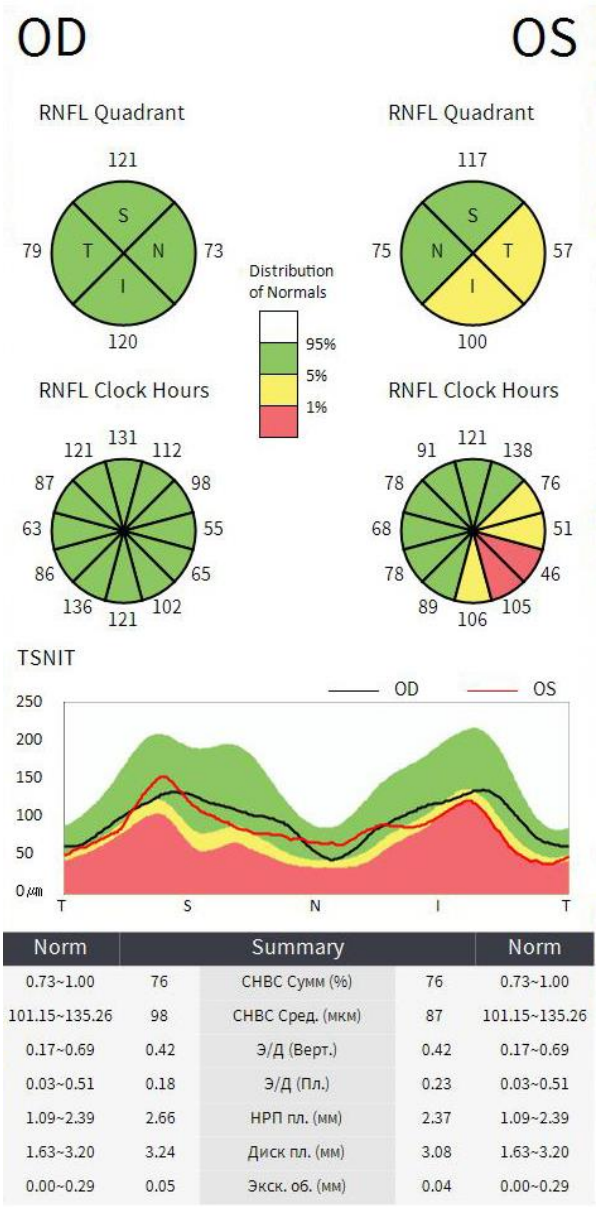
The following image (Fig. 2) shows a comparative analysis of the right and left eyes. In both eyes, RNFL thickness was increased to 164-165 μm (normal is 105,34 ± 11,9 μm), macular volume was 8,89 mm^3 in the right eye and 9,4 mm^3 in the left eye, normal value is 7,15 ± 0.31 mm^3.

For comparison, we present images (Figs. 1, 2) of macular volume and RNFL thickness analysis of a healthy patient B., 23 years old, with uncorrected visual acuity of 1,0 in both eyes. In this case, the macular volume was 6,92 mm^3 in the right eye and 7,06 mm^3 in the left eye, and the average thickness of the RNFL was 99 μm and 98 μm, respectively. Retinal thickness in the macular area is 173/164 μm.



Norm		Summary		Norm
0.73~1.00	64	СНВС Сумм (%)	64	0.73~1.00
100.99~135.10	83	СНВС Сред. (мкм)	81	100.99~135.10
0.17~0.69	0.00	Э/Д (Верт.)	0.00	0.17~0.69
0.03~0.51	0.00	Э/Д (Пл.)	0.00	0.03~0.51
1.09~2.39	2.73	НРП пл. (мм)	2.15	1.09~2.39
1.63~3.20	2.73	Диск пл. (мм)	2.15	1.63~3.20
0.00~0.30	0.00	Экск. об. (мм)	0.00	0.00~0.30

Figure 1. One of the variants of RNFL thickness analysis around the OND using the "RNFL thickness (3,4 mm)" program. White arrows indicate the RNFL, red ones - the direction of the scanner beam around the optic nerve



Norm		Summary		Norm
0.73~1.00	76	СНВС Сумм (%)	76	0.73~1.00
101.15~135.26	98	СНВС Сред. (мкм)	87	101.15~135.26
0.17~0.69	0.42	Э/Д (Верт.)	0.42	0.17~0.69
0.03~0.51	0.18	Э/Д (Пл.)	0.23	0.03~0.51
1.09~2.39	2.66	НРП пл. (мм)	2.37	1.09~2.39
1.63~3.20	3.24	Диск пл. (мм)	3.08	1.63~3.20
0.00~0.29	0.05	Экск. об. (мм)	0.04	0.00~0.29

Figure 2. One of the variants of RNFL thickness analysis around the OND using the program "RNFL thickness (3.4 mm)" of the same patient, comparison with the second eye was performed

Conclusion

The use of OCT, which allows quantitative and objective assessment of even the most insignificant pathologic changes in the retina, opens additional opportunities for early diagnosis and monitoring of the condition of patients with craniocerebral trauma and CGI. OCT allows to determine the thickness of RNFL and the degree of fiber damage in the retina and optic nerve due to traumatic process at the

earliest stage after the trauma, when other traditional ophthalmologic studies (perimetry, visometry, ophthalmoscopy) are uninformative.

As a result of our study we found a significant increase in macular volume, the size of the OND and the thickness of peripapillary fibers of the RNFL in patients with OCT compared to the control group, which was confirmed by the data of optical coherence tomography.

Our study showed that OCT can be used for objective assessment and diagnosis of retinal and optic nerve damage in CGI.

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