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Evaluation of the ganglion cell and inner plexiform layer in children with optic neuritis

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ABSTRACT

Aim of the study: To assess the influence of optic neuritis in children on the thickness of the ganglion cell layer and the inner plexiform layer in six individual segments of the central retina in optical coherence tomography (OCT) examination of the retina and the optic nerve.

Material and methods: The study group consisted of 34 eyes of 26 children hospitalized at the Department of Pediatric Ophthalmology of the University Clinical Center of Prof. K. Gibiński in Katowice due to unilateral or bilateral retrobulbar optic neuritis. The comparative group consisted of 40 eyes of 22 children hospitalized for impairments other than of the visual pathway. Each child had the best distance corrected visual acuity (V) and intraocular pressure (IOP) checked, assessment of the anterior and posterior segment of the eyeball in a biomicroscope before and after pupil dilation, OCT of the macula and optic nerve disc, and ocular biometry. In the study group, all examinations, including OCT, were repeated after 6 months.

Results: There was a statistically significant reduction in the mean GCL + IPL thickness and GCL + IPL thickness in the following segments: superior temporal, superior nasal, inferior temporal and inferior nasal measured after recovery, compared to the measurements performed during optic neuritis. Similar results were recorded for the average RNFL thickness.

Conclusions: After optic neuritis in children, the thickness of the GCL + IPL is reduced only in some segments of the central retina in the OCT. The greatest decrease occurs in the upper and lower nasal segments. Research on a larger group of patients is necessary.

KEY WORDS: optic neuritis, optical coherence tomography of retina and optic nerve, retinal ganglion cells, optic nerve.

INTRODUCTION

Optic neuritis (ON) is an acquired inflammatory process leading to a sudden, usually unilateral and reversible decrease in visual acuity [1]. The condition is quite rare in children, and based on a survey of children in Canada, the estimated annual incidence of ON in children is 0.2 per 100,000 (95% confidence interval: 0.16-0.3) [2]. No studies have been conducted on the epidemiology of ON in the pediatric population in Poland.

Depending on the location of the inflammatory process and the local picture, we distinguish: intraocular optic neuritis (the most common type of optic neuritis in the pediatric population) [3], retrobulbar ON, and inflammation of the optic nerve and retina (neuroretinitis).

Optic neuritis among pediatric patients can be an idiopathic, isolated event or an autoimmune response to infection. However, it may also be a manifestation of an ongoing systemic demyelinating process. In younger children optic neuritis is most commonly seen after infection, immunization or as part of an acute disseminated encephalomyelitis (ADEM) [4, 5].

Among older children, aged over 10-12 years, optic neuritis is often associated with a primary demyelinating disease such as MS or optic neuritis and myelitis (NMO) [6, 7].

Clinical manifestations of ON include decreased visual acuity, eye pain, relative afferent pupillary defect (RAPD), visual field loss, swelling of the optic nerve disc, photopsia (flickering or flashes of light), and loss of color vision disproportional to the loss of visual acuity.

Pediatric patients diagnosed with optic neuritis require not only ophthalmologic, but also a comprehensive general medical examination. It is necessary to exclude CNS compressive lesions and systemic diseases (metabolic, infectious, autoimmune), in the course of which ON is only one

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of the symptoms. It is essential to perform a refraction test after complete accommodative paralysis to rule out amblyopia or accommodative spasm. Auxiliary tests that help in establishing the diagnosis, determining the cause of ON and monitoring the course of the disease include: visual field, MRI, lumbar puncture, serological tests for infectious diseases, antibodies to aquaporin-4 (AQ4-Ab/NMO-Ab) and myelin-oligodendrocyte glycoprotein (MOG-Ab), fluorescein angiography, optical coherence tomography (OCT), and visual evoked potentials (VEP). OCT is a non-invasive, widely available diagnostic tool providing in vivo examination of tissue cross-sections with very high resolution. With OCT, images of the retina and optic nerve can be obtained quickly and accurately, with near microscopic precision, thereby eliminating the dangerous radiation [8] and high-risk general anesthesia necessary for MR imaging in younger children.

In terms of neuro-ophthalmology, particularly useful parameters to be derived from OCT are the thickness of the retinal nerve fiber layer (RNFL) and the retinal ganglion cell layer (GCL), and to date, the most commonly assessed value has been the RNFL. Modern OCT instruments, such as the CIRRUS HD-OCT 5000 (ZEISS, Dublin, CA), have the function to measure GCL thickness. Because of technical problems that prevent accurate separation of the two layers during OCT, the thickness of the ganglion cell layer is estimated as a combination of the ganglion cell layer (GCL) and the inner plexiform layer (IPL). According to various authors, the thickness of GCL + IPL decreases as soon as about 30 days after an episode of ON while the thickness of RNFL decreases after 3-6 months. [9] Additionally, the measurement of GCL + IPL thickness is not affected by initial swelling of the optic disc, swelling of the retinal nerve fiber layer, presence of druses or blood vessels on the optic disc [10]. Severe early atrophy of ganglion cells in the macula may be indicative of optic neuritis in the course of NMO. Small cystic changes in the inner nuclear layer in the macula indicate more severe optic nerve atrophy. However, it should be noted that during the acute phase of extraocular ON, due to axoplasm stasis, the thickness of GCL + IPL and RNFL can increase in as many as 82% of cases [11].

THE AIMS OF THE STUDY WERE:

1. To determine in which segments of the central retina the greatest thinning of the ganglion cell layer and inner retinal plexiform layer (GCL + IPL) occurs after optic neuritis in children.
2. To establish whether measurement of the thickness of the ganglion cell layer and inner retinal plexiform layer (GCL + IPL) is a useful parameter in diagnosing visual pathway damage in children after childhood optic neuritis.
3. To investigate whether there is a correlation between the mean thickness of the ganglion cell layer including the inner retinal plexiform layer (mean GCL + IPL thickness) and the mean thickness of the retinal nerve fiber layer (mean RNFL thickness) in children after optic neuritis.
4. To assess whether there is a correlation between the average thickness of the ganglion cell layer and the inner retinal plexiform cell layer (average thickness of GCL + IPL) and the decrease in visual acuity to distance (V) after optic neuritis in children.

MATERIAL AND METHODS

Based on the opinion of the Bioethics Committee of the Silesian Medical University, in accordance with the Act of December 5, 1996 on the professions of physician and dentist (i.e., Journal of Laws of 2019, item 537, as amended), a routine study is not a medical experiment and does not require the consent of the SUM Bioethics Committee (Decision No. PCN/0022/KB1/110/20). The work was created within the framework of Statutory Contract No. KNW-1-130/K/7/K (contract funded by the grant of the Ministry of Science and Higher Education for "maintenance of research potential") entitled "Evaluation of the clinical value of retinal ganglion cell examination in glaucoma, retinal and optic nerve lesions in children in optical coherence tomography images".

Patients – study group

The study group consisted of 34 eyes of 26 children (19 girls, 7 boys) aged 7 to 17 years (M = 12.29, SD = 3.26) hospitalized at the Department of Pediatric Ophthalmology of the Prof. K. Gibinski University Clinical Center SUM in Katowice for unilateral or bilateral extraocular optic neuritis. Five patients were diagnosed with multiple sclerosis, one with neuromyelitis optica spectrum disorder. Positive serological tests for a history of viral infection (HSV and CMV) were found in two patients. One child was diagnosed with active sinusitis. The mean age of patients diagnosed with MS was 14.4 years (M =14.5, SD = 0.7). In the group of patients younger than 10 years (5 patients aged 7 to 9 years, M = 8, SD = 0) there were 3 boys and 2 girls. In the group of children 10 years of age and older (21 patients aged 10 to 17 years, M = 12.5, SD = 3.5) there were 4 boys and 17 girls. Qualification for the study was preceded by a detailed interview collected from parents and patients, which included the presence of subjective complaints, history of ophthalmic diseases, neurological and systemic diseases and topical medications taken, as well as family history, especially the presence of glaucoma. Even at the initial stage of qualification for the study, several patients were excluded from the study due to the finding of psychosomatic visual disorders.

Inclusion and exclusion criteria

Criteria including the patient in the study group:

1. The presence of a primary episode of retrobulbar optic neuritis.
2. No additional ophthalmic diseases.
3. Ocular biometry 22-24 mm.
4. Age at onset of optic neuritis: 6-18 years.

Criteria excluding the patient from the study group:

1. History of optic neuritis.

2. The occurrence of other congenital and chronic diseases of the eyes and the optic nerve.
3. Presence of diseases of the nervous system other than MS or NMO.
4. Prematurity.
5. Past head injury.
6. Mental diseases.
7. Lack of cooperation making it impossible to take measurements.

Patients – comparative group

The reference standard for adult RNFL thickness is 100.1 ±11.6 μm (n = 328). Due to the lack of built-in Zeiss Stratus OCT normative databases for both GCL+IPL thickness and RNFL thickness covering the under-18 population, we compared the results of the study group with a comparison group. The comparison group consisted of 40 eyes of 22 children (16 girls, 6 boys) aged 7 to 17 years (M = 12.36, SD = 3.60) who had been hospitalized at the Department of Pediatric Ophthalmology of the Prof. K. Gibinski University Clinical Center SUM in Katowice for reasons other than optic neuritis, and who had no visual pathway disorders. The comparison group included 12 girls and 10 boys. The patients were aged 7-17 years, with a mean age of 12.3 years.

Inclusion and exclusion criteria

Criteria including the patient in the comparative group:

1. No ophthalmic diseases related to damage to the visual pathway.
2. Ocular biometry 22-24 mm.
3. Age while hospitalized: 6-18 years.

Criteria excluding the patient from the study group:

1. History of optic neuritis.
2. Prevalence of congenital and acquired diseases of the retina and the optic nerve.
3. Presence of any diseases of the nervous system.
4. Prematurity.
5. Past head injury.
6. Mental diseases.
7. Lack of cooperation making it impossible to take measurements.

Research methods

We performed the following tests in each child from the study and comparative group during hospitalization (measurement 1):

1. distance visual acuity (V) examination using Snellen charts with the best optical correction in constant lighting conditions;
2. testing color vision using Ishihara tables;
3. examination of the intraocular pressure using the non-contact air-puff method;
4. evaluation of the anterior segment of the eyeball in a slit biomicroscope (Haag-Streit, Switzerland) before and after pupil dilation;
5. evaluation of the posterior segment of the eyeball in a slit biomicroscope (Haag-Streit, Switzerland) using an indirect method with a Volk 90 D lens (Volk, USA);
6. testing the average and minimum thickness of the GCL + IPL layer and in six individual segments of the central retina using the Cirrus HD -OCT 5000 apparatus from Carl Zeiss Meditec, Germany;
7. testing the average thickness of the RNFL layer using the Cirrus HD -OCT 5000 apparatus by Carl Zeiss Meditec, Germany;
8. optical biometry of the eyeball using the ZEISS IOL Master 500 apparatus;
9. visually evoked potential VEP using RETIport32, Roland Consult, Germany, carried out in accordance with the standard ISCEV (International Society for Clinical Electrophysiology of Vision).

In the study group, basic ophthalmic examinations, GCL + IPL and RNFL thickness measurements were repeated after 6 months (measurement 2) during a follow-up visit in the ophthalmology clinic. The results of the patients from the study group obtained during hospitalization were compared with the results of the children from the comparative group and with the results obtained during the follow-up visit after 6 months, and then subjected to statistical analysis.

RESULTS

Distance visual acuity

Descriptive statistics for the distance visual acuity in the study group, separately for measurement 1 taken during ON and measurement 2 taken at the follow-up visit, are shown in Table I.

During optic neuritis, best corrected visual acuity assessed by Snellen charts was less than 0.7 in more than 75% of patients in the study group, while after recovery it was greater than 0.8 in more than 75%, and the most common value was V = 1.0.

The Wilcoxon test for the difference between the measurements showed that corrected visual acuity to distance significantly improved ($p < 0.05$) after treatment of optic neuritis (Table II). Improvement was noted for more than 75% of eyes, and the mean recovery was about V = 0.5 (Figure 1, right panel).

Color vision

During optic neuritis, abnormal color vision on Ishihara charts was found in 29 patients (85.3%) in the study group. After treatment, 52.9% of patients improved and only 11 patients (32.4%) were unable to recognize colors correctly. In the comparison group, all patients identified colors accurately.

Intraocular pressure

The mean intraocular pressure in the study group during optic neuritis was 17.11 mmHg, and after optic neuritis it was 15.61 mmHg. In the comparison group, the mean intraocular pressure was 16.2 mmHg.

Table I. Descriptive statistics for distance visual acuity in the study group

Distance visual acuity (V)	M	SD	SE	ME	IQR	Min	Max	Sk.
Measurement 1 (before treatment)	0.38	0.35	0.06	0.3	0.58	0.01	1.0	0.58
Measurement 2 (after treatment)	0.8	0.34	0.06	1.0	0.17	0.01	1.0	–1.44

Table II. Wilcoxon test results for far visual acuity in the study group

Distance visual acuity (V)	Me	IQR	Sk.	Z	P (>|Z|)	R	W	P (>|W|)
Measurement 2 – Measurement 1	0.45	0.7	–0.12	4.6	< 0.001	0.79	0.92	0.015

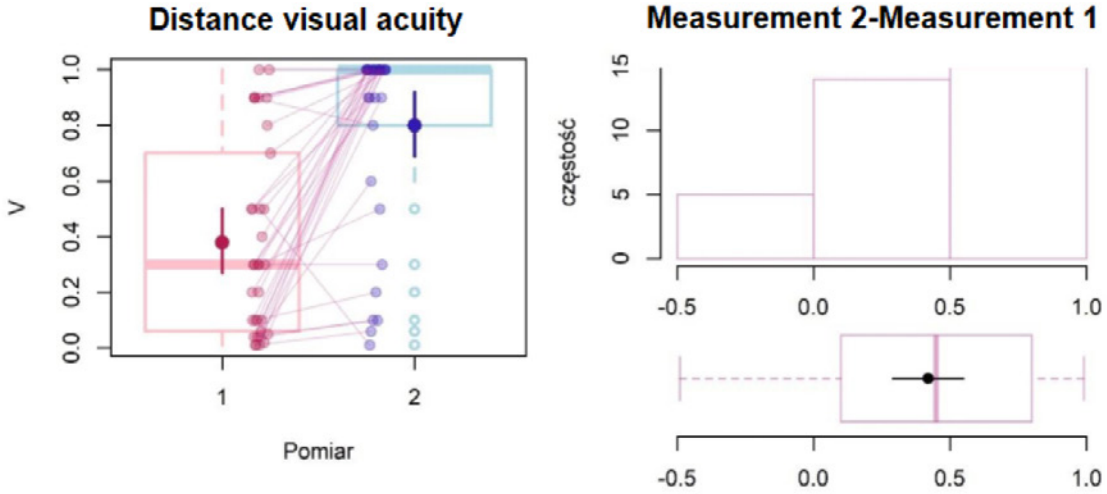

Figure 1. Graphical presentation of the distribution of distance visual acuity measurements in the study group. The dark points are the means and the corresponding lines are the 95% confidence intervals. Bright transparent points connected by lines are pairs of observations for the same eye

Ocular biometry

The mean axial eyeball length of patients in the study group during optic neuritis was 23.11 mm, and 23.34 mm in the comparison group. Control eye biometry tests were not performed.

Thickness of the retinal ganglion cell layer along with the internal plexiform layer and retinal nerve fiber layer

Descriptive statistics for these parameters are presented separately for measurement 2 and measurement 1 in Table III.

The average thicknesses of the ganglion cell layer, inner plexiform layer (GCL + IPL) and retinal nerve fibers (RNFL) were greater during optic neuritis than after recovery. The result of the repeated measures analysis of variance for the measurement factor (during inflammation vs. after nerve inflammation) showed no differences between the measurements, $F(1, 33) = 2.84$, $p = 0.101$, partial $\eta^2 = 0.08$. However, due to the obliquity of the distributions and inconsistency with the normal distribution, as well as the high correlations between the variables tested, this analysis had limited power to detect significant differences [12]. For this reason, despite the lack of significant differences of the multivariate test, a series of Wilcoxon tests were performed separately for each variable. The results of the analyses are summarized in Table IV.

It is important to note that there were six significant differences ($p \leq 0.05$). For the parameters the average thickness of GCL + IPL (M_GCL + IPL) and the thickness of GCL + IPL in the upper temporal (Temp_up_GCL + IPL), upper nasal (Nas_up_GCL + IPL), lower temporal (Temp_low_GCL + IPL) and lower nasal (Nas_low_GCL + IPL) segments there was a decrease in the measurements taken after recovery, compared to the measurements taken during optic neuritis. For each parameter, falls were recorded for most of the studied eyes. The effect size for significant differences varies around medium to large. Analogous results were noted for average RNFL thickness. The largest average decreases in GCL + IPL thickness were recorded in the upper nasal (2.15 μm) and lower nasal (2.14 μm) segments and RNFL medium thickness (8.27 μm). No differences were noted for the following parameters: minimum thickness GCL + IPL (Min_GCL + IPL), thickness GCL + IPL in the upper middle (Mid_up_GCL + IPL) and the lower middle (Mid_down_GCL + IPL) segments. The comparison of parameters between measurements in a graphic form is shown in Figure 2.

Table III. Descriptive statistics for GCL + IPL and RNFL thickness in the study group

Thickness [µm]	M	SD	SE	Me	IQR	Min	Max	Sk.
M_GCL + IPL_2	76.91	10.13	1.74	78	10	50	90	–1.17
M_GCL + IPL_1	78.65	10.71	1.84	80	11.5	38	91	–1.79
Min_GCL + IPL_2	73.83	10.99	1.88	76	9	41	88	–1.42
Min_GCL + IPL_1	73.97	12.06	2.07	76	14	29	88	–1.75
Temp_up_GCL + IPL_2	76.5	8.34	1.43	77.5	9.75	52	90	–0.87
Temp_up_GCL + IPL_1	77.68	11.55	1.98	80.5	10.75	34	91	–1.91
Mid_up_GCL + IPL_2	77.56	10.46	1.79	77.5	10.75	48	92	–1.11
Mid_up_GCL + IPL_1	78.65	12.6	2.16	81.5	12.75	29	93	–2.06
Nas_up_GCL + IPL_2	77.59	11.1	1.9	79	9	49	94	–0.97
Nas_up_GCL + IPL_1	79.74	10.89	1.87	81.5	10.75	50	94	–1.23
Temp_low_GCL + IPL_2	77.06	10.03	1.72	78	11.75	51	92	–1
Temp_low_GCL + IPL_1	78.18	12.6	2.16	80.5	12.5	26	94	–2.23
Mid_low_GCL + IPL_2	76.74	11.22	1.92	78	14	47	90	–1.14
Mid_low_GCL + IPL_1	76.74	13.52	2.32	78.5	14.75	24	93	–1.81
Nas_low_GCL + IPL_2	76.71	11.69	2	80	14	43	90	–1.26
Nas_low_GCL + IPL_1	78.85	11.1	1.9	81	15.25	53	94	–0.88
M_RNFL_GCL + IPL_2	88.82	13.02	2.23	87.5	13.5	54	117	–0.21
M_RNFL_GCL + IPL_1	97.09	18.93	3.25	93.5	17.31	54	145	0.38

Table IV. Wilcoxon test results for GCL + IPL and RNFL thicknesses in the study group

Parameter 2 – parameter 1	Me	IQR	Sk.	Z	$p(>\|Z\|)$	R	W	$p(>\|W\|)$
M_GCL + IPL	–1	4.75	–0.54	–2.5	0.012	–0.43	0.83	< 0.001
Min_GCL + IPL	–1.35	6.25	0.49	–0.78	0.45	–0.13	0.89	0.003
Temp_up_GCL + IPL	–2.5	4	1.14	–2.45	0.013	–0.42	0.74	< 0.001
Mid_up_GCL + IPL	–3	6.75	0.79	–1.88	0.062	–0.32	0.81	< 0.001
Nas_up_GCL + IPL	–3	3	0.98	–3.25	0.001	–0.56	0.72	< 0.001
Temp_low_GCL + IPL	–1.5	4.5	1.57	–2.6	0.008	–0.45	0.74	< 0.001
Mid_low_GCL + IPL	–1	4.75	0.79	–1.02	0.326	–0.17	0.86	< 0.001
Nas_low_GCL + IPL	–2	4	1.86	–3.13	0.001	–0.54	0.78	< 0.001
M_RNFL	–3	6.75	–1.88	–2.95	0.002	–0.51	0.74	< 0.001

Comparison of results of the study group with the comparative group

The descriptive statistics for the distance visual acuity parameter and the GCL + IPL and RNFL thickness parameters in the comparative group are presented in Table V.

Due to significant obliquities in the parameter value distributions during optic neuritis in the study group, differences between groups were tested using the Mann-Whitney *U*-test. The results of these analyses are summarized in Table VI. There were statistically significantly ($p \leq 0.05$) higher values for all parameters in the comparison group, compared with the values of parameters in the study group during optic neuritis, excluding the mean RNFL thickness. For corrected visual acuity to distance, an effect of high magnitude was noted. On the other hand, the effect strengths for GCL + IPL thickness were small. The compared distributions in graphical form are shown in Figure 3.

Correlations between the parameters GCL + IPL, RNFL and visual acuity

The final stage of the analyses examined the relationships between changes in mean GCL + IPL thickness (M_GCL + IPL) and changes in mean RNFL thickness (M_RNFL) and corrected visual acuity to distance (V_to_dali). Variations were defined as differences between the values of a given parameter after and before optic neuritis. Correlations were tested using Spearman's non-parametric rho coefficient due to the presence of outliers in the data. There

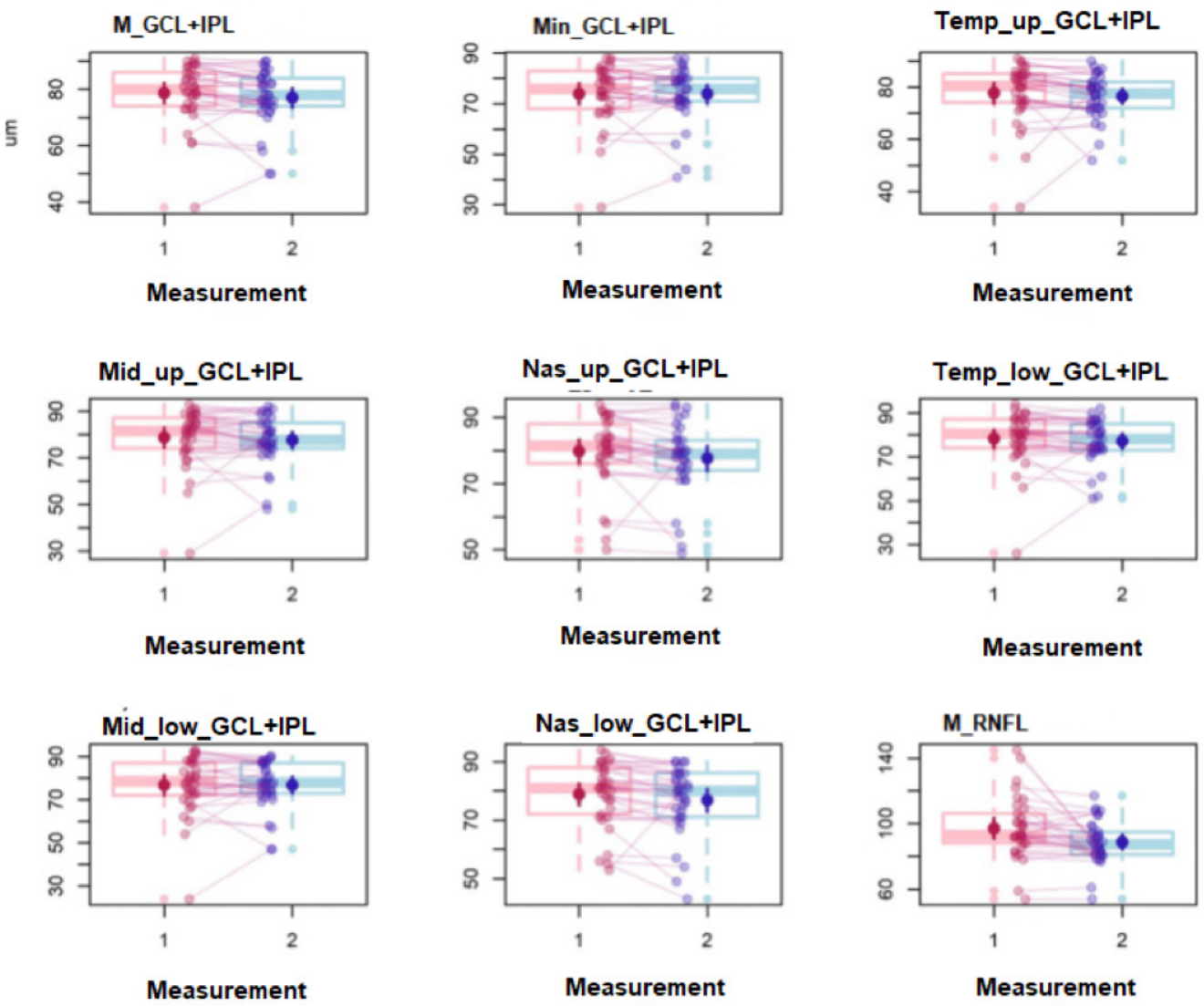

Figure 2. Graphical presentation of the distribution of GCL + IPL and RNFL thickness measurements in the study group. The dark points are the means and the corresponding lines are the 95% confidence intervals. Bright transparent points connected by lines are pairs of observations for the same eye

were no significant relationships between both the change in mean GCL + IPL thickness and the change in mean RNFL thickness, *rho* = 0.31, $p = 0.077$, and between the change in mean GCL + IPL thickness and the change in corrected near visual acuity, *rho* = 0.12, $p = 0.499$. The correlations between the analyzed parameter changes in the form of scatter plots are shown in Figure 4.

DISCUSSION

In 1959, Hierons and Lyle [13] reported pediatric optic neuritis for the first time as completely unique in its presentation. They noted that children with ON were often male, suffered from painless bilateral optic neuritis and severe visual disturbances preceded by prodromal symptoms, and rarely developed MS. These features were clearly distinguished from the typical optic neuritis seen in adults. While increasingly more is known about optic neuritis in adults, ON in children remains a poorly understood disease entity. According to several authors, ON in younger children presents with equal frequency in both sexes [6, 14, 15]. During adolescence, the condition shows a greater prevalence among females (as in adults). In our study, in children younger than 10 years of age, ON was more common in boys, while in this group of older patients it was more common in girls, which is consistent with reports from the literature. In most studies, the average age of patients diagnosed with ON is 9-11 years [4, 14-17]. In the present study, the mean age of patients in the study group was 12.29 years (SD = 3.26). The mean age of patients diagnosed with MS in the study group was 15.6 years (SD = 0.7), which was higher than the mean age of the other children. A meta-analysis of pediatric optic neuritis cases published between 1950 and 2010 by Waldman and colleagues found that each one-year increase in age was associated with a 32% increase in the risk of MS [18]. In comparison with adults,

Table V. Descriptive statistics of the parameters measured in the control group

Parameter	M	SD	SE	Me	IQR	Min	Max	Sk.
V_for_dist	0.96	0.09	0.01	1	0	0.7	1	–2.12
M_GCL + IPL	85.65	6.27	0.99	85.5	7	71	99	0.04
Min_GCL + IPL	82.15	6.15	0.97	82	7.25	67	96	0.02
Temp_up_GCL + IPL	84.9	6.23	0.99	85	8.5	70	97	–0.31
Mid_up_GCL + IPL	86.4	7.15	1.13	86.5	8	67	105	0
Nas_up_GCL + IPL	87.08	7.46	1.18	86	6.5	72	104	0.47
Temp_low_GCL + IPL	85.38	6.15	0.97	84.5	8	70	98	–0.11
Mid_low_GCL + IPL	83.83	6.7	1.06	82.5	8.5	71	98	0.39
Nas_low_GCL + IPL	85.9	7.14	1.13	83.5	8.5	72	101	0.37
M_RNFL	98.55	13.65	2.16	95.5	19	76	140	1.04

Table VI. Results of the Mann-Whitney test comparing the values of the parameters of distance visual acuity, GCL + IPL thickness and RNFL in the study (stud) group during optic neuritis with the parameter values in the comparative (comp) group

Variable	Me	IQR	Sk.	Z	*p* (>|Z|)	*r*	W	*p* (>|W|)
V_for_dist_stud	0.3	0.58	0.58	–6.84	0	–0.8	0.86	0
V_for_dist_comp	1	0	–2.12				0.46	0
M_GCL + IPL_stud	80	11.5	–1.79	–3.06	0.002	–0.36	0.84	0
M_GCL + IPL_comp	85.5	7	0.04				0.98	0.588
Min_GCL + IPL_stud	76	14	–1.75	–3.31	0.001	–0.38	0.85	0
Min_GCL + IPL_comp	82	7.25	0.02				0.98	0.798
Temp_up_GCL + IPL_stud	80.5	10.75	–1.91	–2.99	0.003	–0.35	0.82	0
Temp_up_GCL + IPL_comp	85	8.5	–0.31				0.98	0.587
Mid_up_GCL + IPL_stud	81.5	12.75	–2.06	–2.94	0.003	–0.34	0.81	0
Mid_up_GCL + IPL_comp	86.5	8	0				0.96	0.243
Nas_up_GCL + IPL_stud	81.5	10.75	–1.23	–2.99	0.003	–0.35	0.87	0.001
Nas_up_GCL + IPL_comp	86	6.5	0.47				0.95	0.098
Temp_low_GCL + IPL_stud	80.5	12.5	–2.23	–3.08	0.002	–0.36	0.81	0
Temp_low_GCL + IPL_comp	84.5	8	–0.11				0.97	0.287
Mid_low_GCL + IPL_stud	78.5	14.75	–1.81	–2.58	0.01	–0.3	0.85	0
Mid_low_GCL + IPL_comp	82.5	8.5	0.39				0.95	0.07
Nas_low_GCL + IPL_stud	81	15.25	–0.88	–2.65	0.008	–0.31	0.91	0.009
Nas_low_GCL + IPL_comp	83.5	8.5	0.37				0.95	0.08
M_RNFL_stud	93.35	17.5	0.37	–0.41	0.68	–0.05	0.95	0.164
M_RNFL_comp	95.5	19	1.04				0.92	0.011

children's visual acuity is usually lower during ON. However, in most cases it returns to normal values. About 20% of pediatric patients develop permanent visual acuity impairment after ON [14, 17, 19-22].

In our study, optic neuritis was associated with a decrease in visual acuity of less than 0.7 in more than 3/4 of patients. After 6 months following ON, visual acuity for more than 75% of patients improved significantly, which is typical for ON in children. This may also be due to the fact that only the first incident of ON was considered in this study, and permanent visual acuity damage is usually associated with recurrent episodes. In this study, the study group included only one patient with confirmed NMOSD. His visual acuity at the time of his ON diagnosis was significantly lower than the average visual acuity to distance of the other patients (0.035 vs. 0.4). The patient also did not achieve full restoration of visual acuity.

Besides a decrease in distance visual acuity during optic neuritis, there might be a decline in near visual acuity or

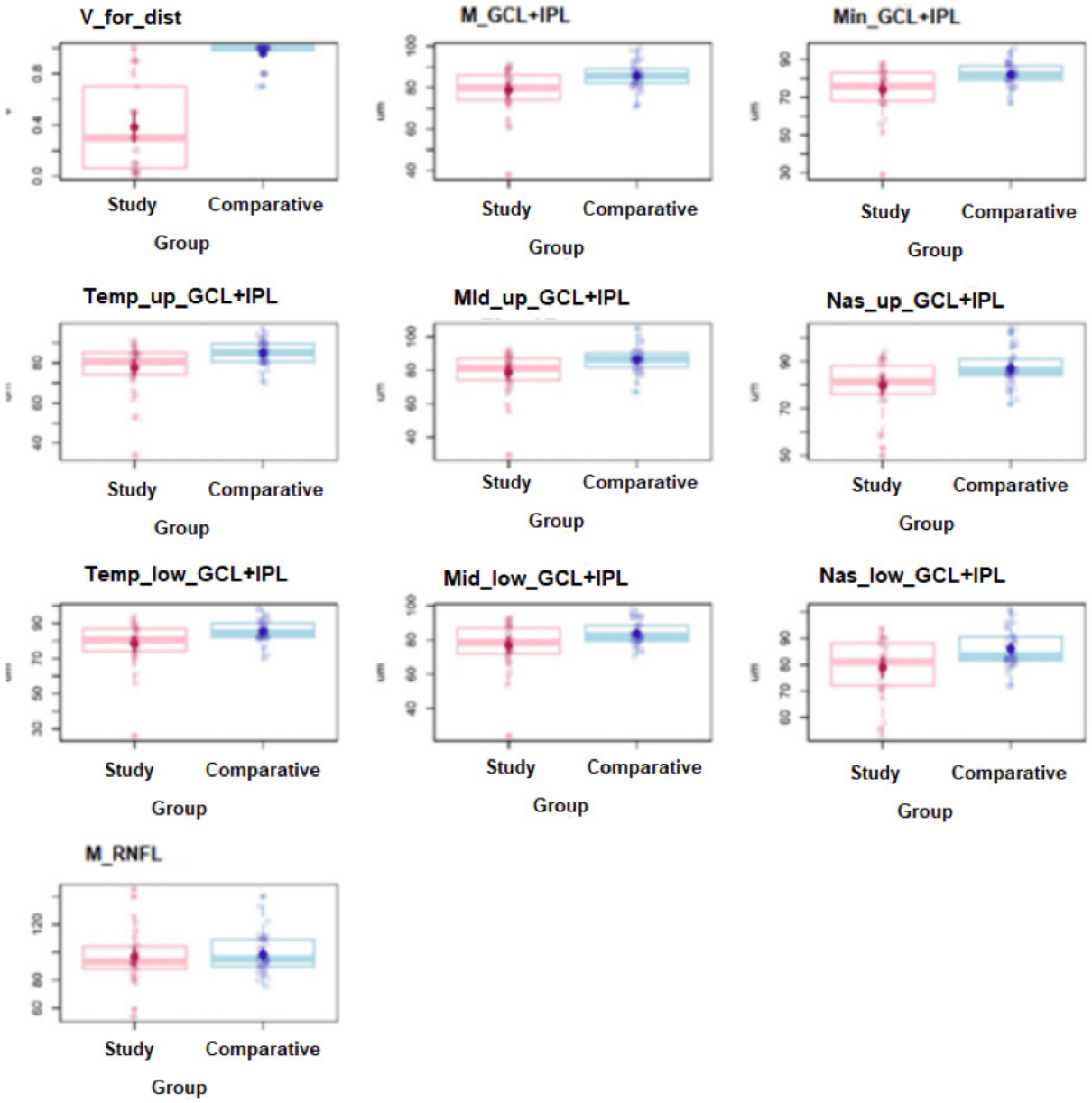

Figure 3. Graphical presentation of the distribution of measurements of distance visual acuity parameters, GCL + IPL and RNFL thickness, divided into research group during optic neuritis and comparative group. The dark points are the means and the corresponding lines are the 95% confidence intervals. Bright transparent points connected by lines are pairs of observations for the same eye

impaired color perception. In our study, we did not evaluate the effect of optic neuritis on near vision, because many patients in the study group had a near visual acuity too low to be objectively assessed. In addition, we found no studies in the literature on pediatric optic neuritis in which near visual acuity was considered. Visual evoked potentials are often used in the diagnosis of optic neuritis. We did not include this examination in this study, because the goal was to focus on the effect of optic neuritis on the thickness of GCL + IPL in the optical coherent tomography examination. Abnormal color perception (especially in the red-green axis) is one of the primary symptoms of optic nerve dysfunction. In the adult population, abnormal color vision was found in 88% of eyes tested in ONTT on Ishihara arrays and in 94% through the more sensitive Farnsworth-Munsell 100-shade test [23]. In our study, ONTT abnormalities of color perception on Ishihara charts occurred in the majority of patients (85.3%). Despite the applied treatment, the abnormalities persisted in 11 patients (32.4%) at the follow-up visit. Bilateral ON is thought to be more common in children than in adults. In our study, bilateral ON occurred in only 8 patients (30.76%), which might be due to the fact that only cases of retrobulbar (not intraocular) ON were considered.

There is a lack of reports in the literature regarding changes in GCL + IPL thickness in individual central retinal segments after optic neuritis in children. In our study, there was

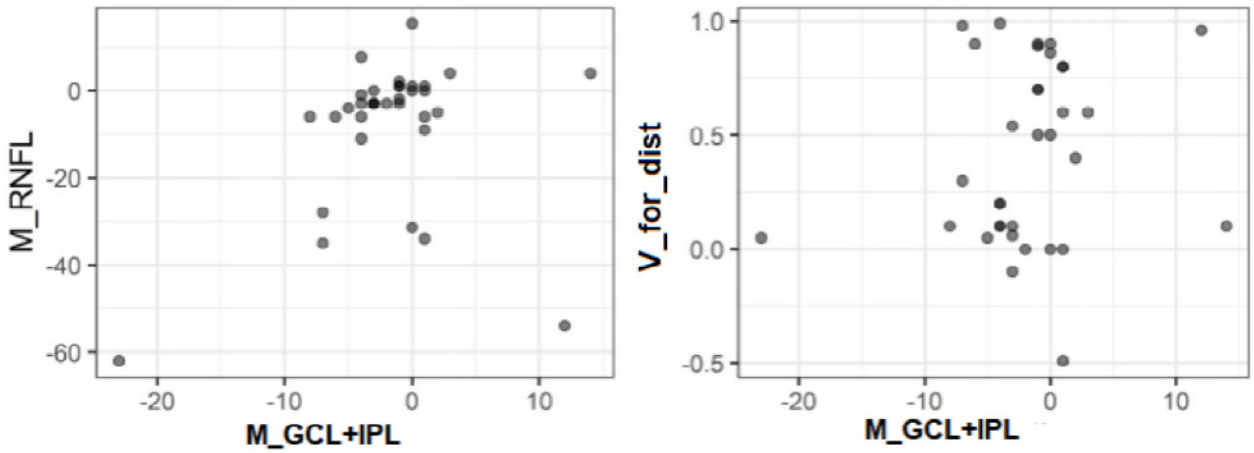

Figure 4. Relationships between changes in the values of the parameters of the average thickness of GCL + IPL and the average thickness of RNFL. A single point represents the difference in a given parameter after inflammation versus the condition during inflammation

a statistically significant decrease in mean GCL + IPL thickness and GCL + IPL thickness in the following segments: superior temporal, superior nasal, inferior temporal and inferior nasal, and for mean RNFL thickness in measurements taken after the inflammation had resolved compared to measurements taken during optic neuritis. The greatest average decrease in GCL + IPL thickness occurred in the middle superior and nasal superior segments, as well as in the average RNFL thickness. There were no differences for minimum GCL + IPL thickness and GCL + IPL thickness in the middle upper and middle lower segments. In our work, the correlation between the change in mean GCL + IPL thickness and changes in mean RNFL thickness and distance visual acuity was also assessed. Changes were defined as the differences between the values of a given parameter after and before optic neuritis.

From this study, significant conclusions should be highlighted. After optic neuritis in children, there is a decrease in the thickness of the ganglion cell layer and inner retinal plexiform layer only in some segments of the central retina and optic nerve. The most significant decrease is observed in the central superior and nasal superior segments. Segmental measurement of the thickness in the ganglion cell layer and inner retinal plexiform layer by optical coherent tomography located in the retina and optic nerve is a useful parameter in diagnosing structural damage to the visual pathway after optic neuritis in children.

There is no significant correlation between the change in the mean thickness of the ganglion cell layer and the inner retinal plexiform layer and the change in the mean thickness of the retinal nerve fiber layer in children during and after optic neuritis. No relationship was observed either between the change in the mean thickness of the ganglion cell layer and the inner retinal plexiform layer and corrected visual acuity to distance during and after optic neuritis in children. Due to the heterogeneous etiology of optic neuritis, which may affect the above results, further studies in this direction are desirable.

DISCLOSURE

The authors declare no conflict of interest.
Statutory Agreement No. KNW-1-130 / K / 7 / K.

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