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STRUCTURE-FUNCTION RELATIONSHIP OF CHANGES IN VISUAL FIELD INDICES WITH QUADRANT AND AVERAGE RETINAL NERVE FIBER LAYER THICKNESS IN THE EYES WITH EXFOLIATION

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SUMMARY – The progressive nature of glaucoma suggests it should be possible to detect structural changes such as retinal nerve fiber layer (RNFL) thickness loss before the condition becomes clinically apparent with visual field (VF) impairment. Therefore, the aim was to analyze RNFL thickness and VF changes in study groups with unilateral exfoliation syndrome (XFS), bilateral XFS and bilateral exfoliative glaucoma (XFG), and compare it with controls. The study included 114 subjects (228 eyes) divided into 4 groups according to the presence of exfoliation: 30 subjects with unilateral XFS (30 with clinically visible XFS and 30 fellow eyes), 24 subjects (48 eyes) with bilateral XFS, 28 (56 eyes) subjects with bilateral XFG, and control group (32 subjects). All subjects underwent VF and RNFL measurements after ophthalmologic examination. Both eyes of unilateral XFS (clinically visible and fellow eye) showed positive correlation between Mean Defect (MD) and square root of Loss of Variance (sLV) and between MD and inferior quadrant RNFL thickness. In bilateral XFS and XFG, there was negative correlation between MD and inferior quadrant RNFL thickness. Inferior, superior and nasal quadrant RNFL thickness was lower in XFG group than in other groups. In bilateral XFS group, the inferior quadrant RNFL thickness was lower as compared with unilateral XFS group (in both eyes). The mean RNFL thickness negatively correlated with MD in bilateral XFS and XFG groups. In conclusion, structural changes before VF impairment have an important role in early detection of glaucoma in subjects at risk.

Key words: *Glaucoma; Nerve fibers; Visual fields; Exfoliation syndrome; Croatia*

Introduction

Exfoliation syndrome (XFS) is the most common cause of secondary open angle glaucoma. It accounts for an estimated 25% of the open angle glaucoma worldwide[1]. The glaucoma associated with XFS is characterized by elevated intraocular pressure (IOP), often with very high levels, and is associated with increased resistance to aqueous outflow. The potential mechanisms of glaucoma in XFS include blockage of the trabecular meshwork by exfoliation material and by liberated iris pigment, trabecular cell dysfunction, and degenerative changes of Schlemm's canal. In addi-

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tion, involvement of the iris, lens and blood vessels leads to anterior segment hypoxia, chronic blood aqueous barrier breakdown, cataract, and abnormalities of ocular blood flow[2]. Exfoliation syndrome is basically bilateral with asymmetric clinical appearance, related with the rate of production and accumulation of the exfoliation material in each eye[3]. Conversion from clinically unilateral to asymmetric bilateral XFS or exfoliative glaucoma (XFG) has already been reported[4-6]. Recent researches have shown that clinically unilateral form is not really unilateral. This condition is rather asymmetric because in clinically unilateral forms, exfoliative material is proven by immunohistochemical methods in iris blood vessels, pupil dilator and conjunctiva without visible exfoliation. Subtle ultrastructural alterations such as microfibrillar deposits in the dilator muscle or in the periphery of iris vessels can be observed virtually in all contralateral eyes in clinically unilateral cases[7], supporting the concept that XFS is a bilateral disease with clinically asymmetric manifestations.

Glaucoma is a slowly progressive optic neuropathy that is usually associated with ocular hypertension. Progressive deformation of the optic nerve head resulting from hypertension leads to cup formation and destruction of the retinal nerve fibers. This neuropathy in turn leads to visual field (VF) impairment. Eyes with XFS are under greater risk of ocular ischemic conditions, not only because of IOP rise and fluctuations, but also because of pathological vascular alterations associated with exfoliation which lead to hypoxia of the eye[2]. It has been proposed that the exfoliation process itself might, to some extent, be a risk factor for glaucomatous optic disc changes[8]. The progressive nature of glaucoma suggests it should be theoretically possible to detect structural changes in the retina and optic nerve before the condition becomes clinically apparent with VF loss[9].

Before there is a detectable change on VF, morphological changes can already exist, such as retinal nerve fiber layer (RNFL) thickness loss. This happens in the eyes at risk especially with exfoliation and it is the main sign of early glaucomatous damage. Therefore, the aim of the study was to compare RNFL thickness and VF changes in the groups of subjects with unilateral and bilateral XFS and with bilateral XFG. The groups of subjects were compared with healthy subjects in order to determine differences between them.

Subjects and Methods

This prospective study was performed between January 2012 and December 2013 at the Sestre milosrdnice University Hospital Center, Department of Ophthalmology, Zagreb, Croatia. The study included 114 subjects (228 eyes) divided into 4 groups according to the presence of exfoliation: 30 subjects with unilateral syndrome, 24 subjects with bilateral syndrome, 28 subjects with bilateral glaucoma, and control group without the presence of glaucoma or syndrome (32 subjects). The group with unilateral syndrome (60 eyes) were divided into two subgroups of 30 eyes depending on whether biomicroscopically detectable exfoliation or no detectable exfoliation was found in the contralateral (fellow) eye. All subjects were older than 50 years. The Hospital Ethics Committee approved the study and an informed consent was obtained from all subjects in writing. All subjects underwent complete ophthalmologic examination including the following: medical history (including ocular and family histories), best corrected visual acuity according to Snellen, slit lamp examination, Goldmann applanation tonometry, gonioscopy, and biomicroscopy with a plus 78-D lens. Standard VF testing (Octopus® Visual Field analyzer with G standard white/white Dynamic program; Haag-Streit AG, Switzerland) was performed and changes of Mean Defect (MD) and square root of Loss of Variance (sLV) were recorded. All eyes underwent optical coherence tomography (OCT) using spectral-domain high definition OCT (Cirrus HD-OCT, Carl Zeiss Meditec, Dublin, CA, USA) after pupillary dilation with 10% phenylephrine hydrochloride. The RNFL thickness was obtained using the Optic Disc Cube protocol 200x200. In the study, we compared the measured mean and quadrant RNFL thickness with MD in automated VF, which is the most important index related to global damage in glaucoma.

In each participant, all examinations were performed during a single day.

The main inclusion criteria were the appearance of unilateral or bilateral XFS and the existing bilateral XFG.

Exfoliation syndrome was defined as the presence of exfoliation material on the anterior lens capsule or at the pupillary border, which was detected biomicroscopically after pupillary dilation. In this study, XFS

subjects were those without glaucomatous disc changes or VF defects, while XFG subjects also had these changes and treatable IOP besides exfoliation. Healthy subjects as a control group were subjects aged above 50 years without the presence of exfoliation and without any glaucomatous changes. This group of subjects included those who visited our Department for routine ophthalmologic evaluation.

Exclusion criteria were the presence of any ocular disease that might interfere with the VF test results or RNFL thickness loss, such as corneal opacities, significant cataracts precluding clear fundus viewing, retinal lesions, history of ischemic, compressive or inflammatory optic neuropathies, refractive errors higher than ±4 diopters, previous ocular surgery, ocular inflammation, and trauma.

Statistical analysis

Results were expressed in the parameters of descriptive statistics, absolute and relative frequencies for qualitative variables, and for quantitative variables we used arithmetic mean and standard deviation (SD), as well as median, minimal and maximal values in cases where distribution did not follow gaussian curve.

The χ^2-test was used on analysis of differences of qualitative variables among the groups. Correlation between functional and structural parameters was studied using Spearman's correlation coefficient. Statistical significance and correlation was set at 5%.

Results

In the total of 114 subjects, there were 54 (47.37%) men and 60 (52.63%) women. There were 12 (40.00%) men and 18 (60.00%) women in the unilateral XFS group, and 14 (58.33%) men and 10 (41.67%) women in the bilateral XFS group. In the bilateral XFG group, there were 14 (50.00%) men and 14 (50.00%) women. In the control group, there were 14 (43.75%) men and 18 (52.63%) women.

The mean (±SD) age was 80.39±4.04 years in the bilateral XFS group; 77.67±5.79 in the unilateral XFS group; 71.25±5.96 in the bilateral XFG group; and 75.69±5.68 in the control group of healthy subjects.

In the XFG group, 7 of 56 (12.5%) eyes had normal RNFL thickness in inferior quadrant, 20 of 55 (35.71%) eyes in superior quadrant, 52 (92.86%) eyes in nasal quadrant, and 39 (69.64%) eyes in temporal quadrant. In the bilateral XFS group, 27 of 48 (56.25%) eyes had normal RNFL thickness in inferior quadrant, 46 (95.83%) eyes in superior quadrant, 44 (91.67%) eyes in nasal quadrant, and 46 (95.83%) eyes in temporal quadrant. In the unilateral XFS group, there were 25 of 30 (83.33%) eyes with visible XFS and 26 of 30

Table 1. Values of examined variables in study groups

	Unilateral XFS (fellow eyes) (n=30)	Unilateral XFS with exfoliation (n=30)	Bilateral XFS syndrome (n=48)	Bilateral XFG (n=56)	Control (n=64)	
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	
Inferior RNFL thickness (μ)	98±10.6	98.3±11.2	94.4±11.5	73.0±13.9	103.8±11.5	1.5
Superior RNFL thickness (μ)	99.6±10.6	98.3±10.4	102.5±14.8	84.0±9.2	104.4±7.5	7.5
Nasal RNFL thickness (μ)	74.4±7.4	74.1±8.5	73.0±8.3	58.5±7.2	59.8±9.6	9.6
Temporal RNFL thickness (μ)	60.8±8.7	61.1±7.8	58.5±8.5	55.3±13.1	59.1±7.6	7.6
Mean RNFL thickness (μ)	83.7±6.0	83.0±6.0	81.8±5.4	69.3±10.3	82.3±4.9	4.9
MD* (dB)	0.5 (0-4)	2.0 (0-10)	2.0 (0 - 2)	10.0 (2-22)	1.0 (0-3)	
sLV * (dB)	2 (1-4)	2.0 (1-11)	2.0 (1-3)	2.0 (2-9)	2.0 (2-2)	

MD = Mean Defect; sLV = square root of Loss of Variance; XFS = exfoliation syndrome; XFG = exfoliation glaucoma; RNFL = retinal nerve fiber layer; *median (min-max)

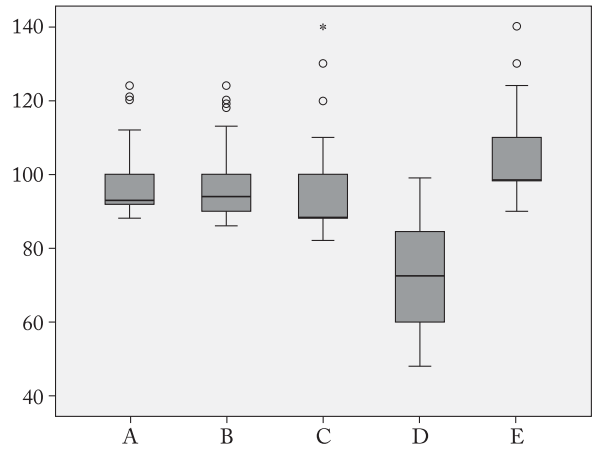

*Fig. 1. Inferior RNFL quadrant thickness among study groups (**reference values, 89.4-138.3 μ).*

(A) unilateral PEX syndrome – fellow eye; (B) unilateral PEX syndrome – clinically manifested; (C) bilateral PEX syndrome; (D) bilateral PEX glaucoma; (E) controls; o = outlier (1.5* interquartile range); *outlier (3* interquartile range)

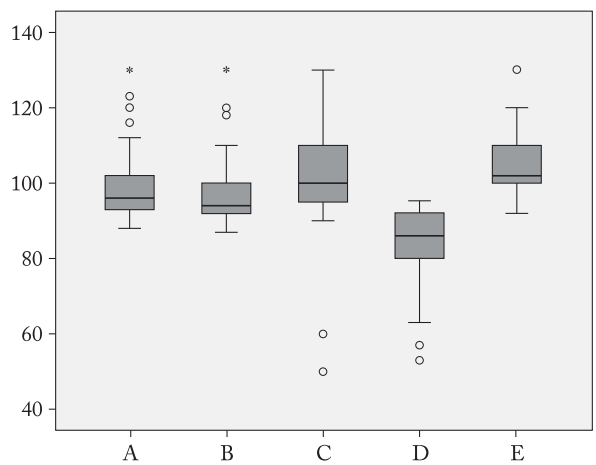

*Fig. 2. Superior RNFL quadrant thickness among study groups (**reference values, 88.9-136.7 μ).*

(A) unilateral PEX syndrome – fellow eye; (B) unilateral PEX syndrome – clinically manifested; (C) bilateral PEX syndrome; (D) bilateral PEX glaucoma; (E) controls; o = outlier (1.5* interquartile range); *outlier (3* interquartile range)

(86.67%) fellow eyes without visible exfoliation with normal RNFL thickness in inferior quadrant. In this group, there were 27 of 30 (90.00%) eyes with visible XFS and 29 of 30 (96.67%) fellow eyes with normal RNFL in superior quadrant. In nasal and temporal quadrants, all eyes from this group had normal RNFL thickness (100%).

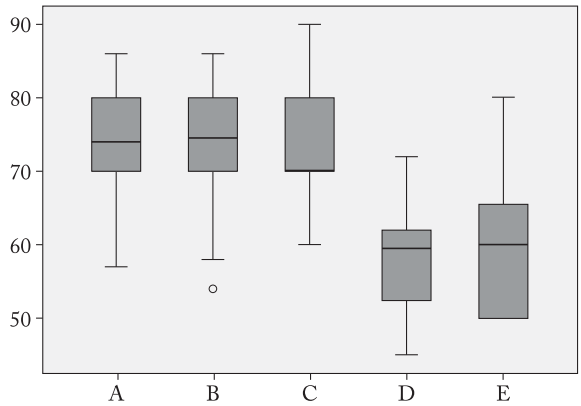

*Fig. 3. Nasal RNFL quadrant thickness among study groups (**reference values, 50.0-86.2 μ).*

(A) unilateral PEX syndrome – fellow eye; (B) unilateral PEX syndrome – clinically manifested; (C) bilateral PEX syndrome; (D) bilateral PEX glaucoma; (E) controls; o = outlier (1.5* interquartile range)

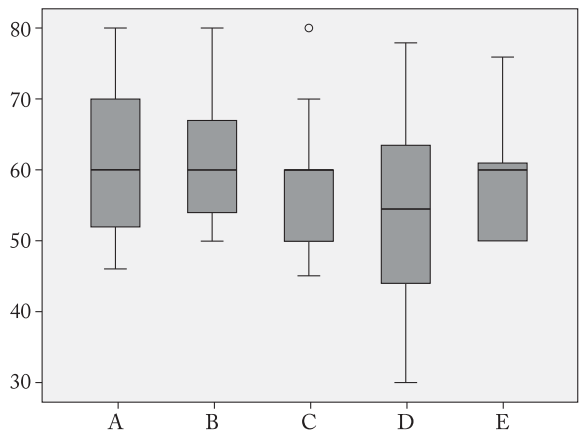

*Fig. 4. Temporal RNFL quadrant thickness among study groups (**reference values, 45.1-82.2 μ).*

(A) unilateral PEX syndrome – fellow eye; (B) unilateral PEX syndrome – clinically manifested; (C) bilateral PEX syndrome; (D) bilateral PEX glaucoma; (E) controls; o = outlier (1.5* interquartile range)

In the control group, there were 63 of 64 (98.44%) eyes with normal RNFL thickness in inferior quadrant, while in other quadrants all eyes had normal RNFL (100%).

Analysis of the mean RNFL thickness showed that the smallest number of eyes were within the reference values in the XFG group (9 of 56; 16.07%), followed by bilateral XFS (32 of 48; 66.67%) and unilateral XFS (the same percentage in clinically visible and fellow eye, 22 of 30; 73.33%).

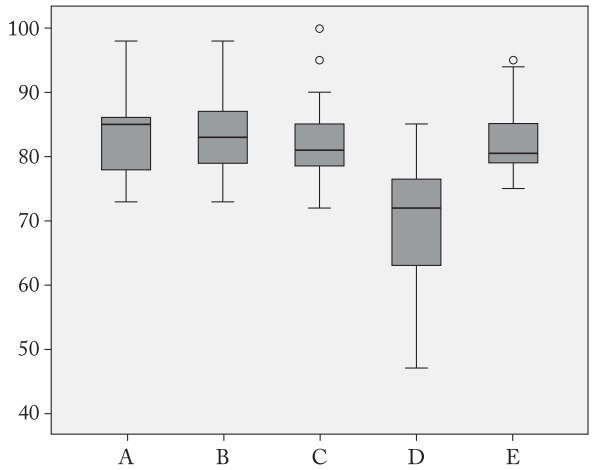

*Fig. 5. Mean RNFL thickness among study groups (**reference values, (>80).*

(A) unilateral PEX syndrome – fellow eye; (B) unilateral PEX syndrome – clinically manifested; (C) bilateral PEX syndrome; (D) bilateral PEX glaucoma; (E) controls; o = outlier (1.5* interquartile range)

In the control group, there were 63 of 64 (98.44%) eyes with reference mean RNFL thickness value.

Table 1 shows the values of examined variables (mean and quadrant RNFL thickness and VF indices) in the groups of subjects. Comparison of RNFL thickness in quadrants among groups of subjects is illustrated in Figures 1-4. The mean RNFL thickness is shown in Figure 5. Table 2 shows correlation of MD with sLV, mean and quadrant RNFL thickness in study groups.

In the group of unilateral XFS, both fellow and clinically visible eyes showed that with the increase of MD value, there was a significantly higher value of sLV (p=001; p=0.008), as in inferior RNFL quadrant thickness (p=0.045; p=0.030). In bilateral XFS, with increase of MD values there was a significant decrease of inferior RNFL quadrant thickness (p<0.001) and superior quadrant thickness (p<0.001). In patients with XFG and increased MD value, sLV also increased (p<0.001) but inferior quadrant thickness decreased (p<0.001). The mean RNFL thickness was significantly linked to MD in unilateral XFS (p=0.008), bilateral XFS (p=0.001) and bilateral XFG (p=0.001), but increase in MD values showed negative correlation with the mean RNFL thickness only in the bilateral XFS and XFG groups.

Discussion

The glaucomas are chronic, progressive optic neuropathies that have in common characteristic morphological changes in the optic disc and RNFL. Functional changes detectable as VF loss are associated with these changes. The gold standard in glaucoma diagnosis are functional changes proven with standard automated perimetry (SAP) and morphological changes of

Table 2. Correlation of MD with sLV and structural parameters

	MD/Unilateral XFS (fellow eye) (n=30)		MD/Unilateral XFS with exfoliation (n=30)		MD/Bilateral XFS (n=48)		MD/Bilateral XFG (n=56)		MD/Control (n=64)	
	r	p	r	p	r	p	r	p	r	p
sLV (dB)	**0.54**	0.002	**0.48**	0.008	0.09	0.554	**0.57**	<0.001	-0.11	0.370
Inferior RNFL thickness (μ)	**0.37**	0.045	**0.40**	0.030	**-0.57**	<0.001	**-0.52**	<0.001	**-0.39**	0.002
Superior RNFL thickness (μ)	0.15	0.423	0.33	0.072	**-0.52**	<0.001	-0.17	0.193	-0.06	0.619
Nasal RNFL thickness (μ)	0.02	0.931	-0.13	0.490	-0.10	0.500	**0.31**	0.020	**-0.34**	0.006
Temporal RNFL thickness (μ)	-0.35	0.057	-0.10	0.592	-0.14	0.351	**-0.46**	<0.001	-0.20	0.120
Mean RNFL thickness (μ)	0.15	0.438	**0.48**	0.008	**-0.46**	0.001	**-0.64**	<0.001	-0.40	0.001

MD = Mean Defect; sLV = square root of Loss of Variance; XFS = exfoliation syndrome; XFG = exfoliation glaucoma; RNFL = retinal nerve fiber layer; p<0.05

optic disc. Structural changes on optic disc may occur prior to functional changes in VF, which is proven by imaging techniques such as OCT. The majority of published scientific papers dealing with diagnostic precision of OCT estimated the ability of the device to distinguish patients with glaucomatous VF damage from healthy population. Although these papers confirm the value of devices, they also have some limits. It is proven that a substantial number of retinal ganglion cells have to be damaged before it can be detected with SAP. In their study, Quigley *et al*. suggest that VF damage, analyzed with SAP, can be detected after damage to 30% of ganglion cells[10]. Harweth *et al*. suggest that 40%-50% of damage to ganglion cells is needed, so that the loss of retinal sensitivity would exceed the usual 95% confidence interval (95% CI)[11]. It limits diagnostic value of RNFL thickness measurement by OCT in subjects with early and moderate defects in VF. However, early detection of glaucoma is of great diagnostic value for patients without VF damage, in a condition known as preperimetric glaucoma. In their study, Sommer *et al*. claim that 60% of patients with ocular hypertension lose RNFL thickness up to 6 years prior to the appearance of VF damage recorded by SAP, but 88% of patients have recorded loss of RNFL thickness during VF loss recorded by SAP[12]. In the Ocular Hypertension Treatment Study, structural optic disc changes were detected prior to or during VF loss in 60% of patients[13]. These patients with preperimetric glaucoma have greater contribution of structural changes in comparison to functional disorders[14]. Therefore, many studies base glaucoma diagnosis on the presence of preperimetric changes.

The key in glaucoma management is early detection due to the fact that detection in the earliest stage has greatest success in lowering irreversible visual function damage.

The present study analyzed 114 subjects (228 eyes) divided into 4 groups based on the presence of pseudoexfoliation in the eye, be it unilateral or bilateral XFS or bilateral XFG, while the control group included subjects without exfoliation and without glaucoma.

When analyzing values of the examined variables by groups, subjects without functional changes showed structural damage, while in subjects with VF defects greater structural damage was recorded (Table 1, Figs. 1-5). The measured values of RNFL thickness in the group with bilateral XFG were lower than in other groups (Table 1).

Medeiros *et al*. pointed out some limitations of using OCT in the measurement of RNFL thickness[15]. It has been shown that subjects with larger optic disc have greater RNFL thickness values, while subjects with smaller optic disc have lower RNFL thickness. This correlation was also supported by histologic studies, which found a large number of nerve fibers in large optic nerve head[16]. Alternative explanation of lower diagnostic OCT value in subjects with large optic disc can be the fact that RNFL thickness is measured in the area closer to the optic nerve head.

In his study, Rao examined patients with bilateral and unilateral XFS and concluded that the subjects with bilateral XFS had a significantly thinner RNFL than subjects with unilateral XFS. Those subjects had normal IOP values and did not have clinically visible glaucomatous damage, and also matched with the groups of subjects with unilateral and bilateral XFS. Conclusions of the study suggest an IOP independent mechanism for ischemic neuropathy in exfoliative eyes (ischemic episodes which lead to glaucomatous damage are likely to be the result of change in blood vessels in XFS)[17]. Electron microscopy confirmed the presence of exfoliation material in fellow eye with unilateral XFS[18]. Another study reports that patients with unilateral XFS had the same IOP value on both eyes during the follow up. Changes in optic nerve head were only recorded in the eyes with clinically visible exfoliation. This proves that exfoliative process can represent a risk factor for optic disc damage development. In addition, other factors participate in the pathogenesis of glaucoma, such as dispersion and accumulation of melanin granules, vascular factors, and changes in connective tissue of lamina cribrosa[19].

The research by Radius showed thinner RNFL in the eyes with exfoliation in comparison to control group without exfoliation which were of approximately the same age and fellow eyes without exfoliation in bilateral XFS[20]. Correlation of RNFL thinning and possible glaucomatous damage in these eyes can only be confirmed by long term follow up[21].

Our study results showed that in unilateral XFS, both eyes (clinically visible and fellow eye) MD and sLV correlated positively with the inferior quadrant thickness. However, this was not the case in bilateral XFS, especially in the case of XFG, where we found negative correlation between structural and functional parameters. For this XFG group, it was expected due to the presence of glaucoma (Table 2). These structural

changes in bilateral XFS group have an important role in early detection of glaucoma for any subjects who are at risk.

The inferior, superior and nasal quadrant RNFL thickness was lower in XFG group than in other groups. In bilateral XFS group, there was lower inferior quadrant RNFL thickness than in the unilateral XFS group (both eyes). In unilateral XFS group, both eyes (clinically visible and fellow eye) showed approximately the same value (Table 1).

There is a great number of evidence that subjects with glaucoma can be detected with RNFL thickness measurement by quadrants. Studies that assessed diagnostic value of few OCT parameters showed the lower quadrant thickness to be the best indicator for distinguishing healthy eyes from the eyes with early to moderate VF defects, with 67%-89% sensitivity and specificity higher than 90%[22-24].

Colen and Lemij suggest that the mean RNFL thickness is the best indicator for early glaucoma detection[25]. A study by Taliantzis *et al*. demonstrated significant correlation between the mean RNFL thickness and VF indicators[26]. Differences among studies were probably caused by different characteristics of subjects, for example, stage of VF damage.

In his histologic paper, Radius reports that RNFL is thicker in the peripapillary part in relation to periphery. RNFL is also thicker in superior and inferior quadrants, and thinner in nasal and temporal quadrants, which can be explained by arcuate order of nerve fibers, which converge towards optic nerve head. Histologic studies of RNFL are important in order to confirm its thickness measured by noninvasive methods such as OCT. RNFL thickness in peripapillary section matches the physiological shape of neuroretinal rim optic nerve head, which is thickest on the inferior sector, followed by superior, nasal and temporal sectors[20]. This sequence of disc sectors has been abbreviated as the ISNT rule.

In human enucleated eyes with absolute glaucoma, Dichtl *et al*. found the average value of 40 μ in the remaining RNFL, without significant difference among quadrants[27]. It is considered that this matches glial tissue of RNFL, which represents 20%-30% of total RNFL thickness in normal eyes.

Different factors can correlate with the loss of RNFL thickness that originates with glaucoma. Quigley *et al*. have shown that sectoral differences in the structure of lamina cribrosa can be related to the order of nerve fiber loss, which originates from glaucoma[28]. Lamina cribrosa demonstrates larger holes and soft connective tissue among them in superior and inferior optic disc sector in comparison with nasal and temporal sectors. This configuration causes larger deformation of lamina cribrosa in superior and inferior sectors of optic disc, which can be related to larger damage to axons in these sectors. With IOP increase, inferior and superior parts of lamina cribrosa suffer greater deformation because of straining. It occurs because of soft connective tissue that leads to higher compression and axonal damage in these sectors. The fact is that Quingley *et al*. demonstrated pronounced deformation of lamina cribrosa towards posteriorly in superior and inferior sectors of enucleated human eyes with glaucoma[27]. This finding was confirmed by other authors as well[29].

In our study, the mean RNFL thickness showed negative correlation with MD in eyes in bilateral XFS and XFG (Table 2). In the bilateral XFS group, this might be a valuable indicator for early glaucoma damage (preperimetric glaucoma), while in the XFG group it denotes severe damage.

Likewise our study, Lopez-Pena *et al*.[30], Schumann *et al*.[31], and Hoh *et al*.[32] published results that support the statement on strong correlation between OCT indicators and SAP with higher correlation to diffuse damage of VF represented by MD. In their results, they emphasized that the higher the damage, the stronger was the correlation between VF and OCT parameters.

The importance of and relation between functional and structural diagnostic methods are currently the subject of research in recent glaucoma diagnosis.

Conclusion

In everyday clinical practice, special attention should be paid to eyes with exfoliation regardless of IOP values and glaucoma damage. Structural changes such as RNFL thickness loss can occur with or without VF changes in those eyes. The same changes are to be expected in both eyes in subjects with unilateral XFS.

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Sažetak

STRUKTURNO-FUNKCIJSKI ODNOS PROMJENA POKAZATELJA VIDNOG POLJA S KVADRANTNOM I PROSJEČNOM DEBLJINOM MREŽNIČNOG SLOJA ŽIVČANIH VLAKANA U OČIMA S EKSFOLIJACIJOM

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Progresija glaukoma upućuje na to da se strukturne promjene kao što je gubitak mrežničnog sloja živčanih vlakana mogu otkriti prije nego što nastupi oštećenje vidnog polja. Cilj rada je bio analizirati debljinu sloja živčanih niti i promjene u vidnom polju u skupinama ispitanika s jednostranim i obostranim eksfolijativnim sindromom i obostranim eksfolijativnim glaukomom te ih usporediti s kontrolnom skupinom. Kod 114 ispitanika (228 očiju) podijeljenih u 4 skupine prema prisutnosti eksfolijacije: 30 ispitanika s jednostranim sindromom (30 s klinički vidljivim sindromom i 30 pratećih očiju), 24 ispitanika (48 očiju) s obostranim eksfolijativnim sindromom, 28 (56 očiju) ispitanika s obostranim glaukomom i 32 ispitanika u kontrolnoj skupini učinjeno je vidno polje i mjerenje debljine živčanog sloja mrežnice nakon oftalmološkog pregleda. Oba su oka jednostranog eksfolijativnog sindroma (klinički vidljivog i kod pratećih očiju) pokazala pozitivnu korelaciju između srednjeg defekta i pokazatelja lokaliziranog defekta vidnog polja te srednjeg defekta i donjeg kvadranta debljine mrežničnog sloja živčanih niti. U obostranom eksfolijativnom sindromu i obostranom glaukomu postojala je negativna korelacija između srednjeg defekta vidnog polja i debljine živčanih niti donjeg kvadranta. U obostranom eksfolijativnom sindromu postojalo je stanjenje mrežničnog sloja živčanih stanica donjeg kvadranta u odnosu na ispitanike s jednostranim eksfolijativnim sindromom (u oba oka). Prosječna debljina živčanog sloja mrežnice bila je u negativnoj korelaciji s prosječnim defektom vidnog polja u obostranom eksfolijativnom glaukomu i obostranom sindromu. U zaključku, strukturne promjene prije pojave oštećenja vidnog polja imaju značajnu ulogu u ranom otkrivanju glaukoma kod osoba koje spadaju u rizičnu skupinu.

Ključne riječi: *Glaukom; Živčana vlakna; Vidna polja; Eksfolijativni sindrom; Hrvatska*