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Refraction and the axial length of the eyeball in patients with the optic disc drusen

Refrakcja i długość gałki ocznej u pacjentów z druzami tarczy nerwu wzrokowego

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Summary: Purpose: The aim of the study was to demonstrate the relationship between the optic disc drusen (ODD) and the axial length of the eyeball as well as refractive error.
Material and methods: We examined prospectively 40 patients with ODD, 18 men and 22 women, age range from 34 to 69 years. All subjects underwent full ophthalmic examination, visual field testing and color-coded duplex sonography of the ocular vessels. Refraction was determined with an autorefractometer (Topcon RM-8000B) and further refined subjectively. Spherical equivalent refraction was calculated as the spherical dioptre plus one half of the cylindrical dioptre. Axial lengths were measured with a Sonomed ultrasound scanner model E-Z Scan AB5500.
Results: Clinical signs were observed in 65% of the eyes with drusen, among them, 38% had symptoms of visual acuity loss and all had visual fields defects. There were 21 eyes (18 eyes with and 3 without drusen), with a recorded refractive error. Significant differences in hyperopia were observed between the eyes with and without drusen ($p = 0.048$). The rate of occurrence of myopia did not differ significantly between affected and unaffected eyes ($p = 0.06$).
The mean spherical equivalent refraction and axial dimensions of the eye differed significantly among the groups of eyes with and without drusen ($p<0.05$). Significant differences in mean values of peak-systolic and end-diastolic velocities ($p<0.001$) as well as in the resistivity index ($p = 0.047$) were observed between eyes with and without drusen.
Conclusions: The optic disc drusen are often associated with shorter and hyperopic eyes. This anatomical conditions and vascular factors may contribute to pathogenesis of drusen.

Key words: optic disc drusen, refractive error, axial length.
Słowa kluczowe: druzy nerwu wzrokowego, wady refrakcji, długość osiowa.

Introduction

Optic disc drusen (ODD) are hyaline-like deposits localized in the prelaminar part of the optic nerve. They occur in approximately 2% of the population and are transmitted as an autosomal dominant trait (1).

Even though the pathogenesis of ODD remains unknown, the most accepted theories suggest an alteration in ganglion cell axoplasmatic transport (2,3). Disturbed axon metabolism can lead to gradual calcification of their cellular mitochondria and thus axon membranes rupture and mitochondria pass into the extracellular space, where they undergo further calcification and fuse into larger complexes that form drusen. The narrow scleral canal, which is more frequently observed in eyes with optic disc drusen, is considered an additional risk factor in pathogenesis of ODD (4). According to this theory, a small scleral canal physically compresses the optic nerve, blocking axoplasmatic flow, leading to ganglion cell axonal damage and ganglion cell death.

Many other clinical aspects, such as the visual field (5,6), the thickness of the retinal nerve fibre layer (7,8) or visual evoked potential (9) have been reported in patients with drusen. In this study, we assessed the other clinical characteristics, such as the axial length of the eye and refractive error, which have not hitherto been reported in patients with ODD. We attempted to determined whether there are any differences in biometric and refractive characteristics of eyes with drusen and unaffected fellow eyes.

Material and methods

We examined prospectively all patients with ODD admitted to the Department of Ophthalmology of the Medical University in Bialystok, between 2002 and 2008. The study was approved by the University Institutional Review Board (according to the guidelines of the Helsinki Declaration),and all patients gave written consent for the use of their clinical material for publication.

Our study group included 40 patients, 18 men and 22 women, age range from 34 to 69 years (mean 49.92 years). All subjects were examined by one ophthalmologist.

We recorded the following data: age, sex, visual acuity (VA), refractive error, color perception, intraocular pressure (IOP), presence of an afferent pupillary defect, appearance of the optic disc, and axial dimensions of the eye. Refraction was determined with an autorefractometer (Topcon RM-8000B), and further refined

subjectively. Myopia was defined as a spherical equivalent refraction ≤ -0.75 D; hyperopia – spherical equivalent refraction ≥ +0.75 D, and emmetropia – spherical equivalent refraction > -0.75 D and < +0.75 D. Spherical equivalent refraction was calculated as the spherical dioptre plus one half of the cylindrical dioptre. Axial lengths (AL) were measured with a Sonomed ultrasound scanner model E-Z Scan AB5500 after pupil dilatation.

The appearance of the optic disc was determined using indirect slit-lamp biomicroscopy with Volk lens and indirect ophthalmoscopy. If the optic disc appeared abnormal, the eye was evaluated with B-scan ultrasonography (Sonomed E-Z scan AB5500), and fluorescein angiography was performed (Kowa VX-10 Fundus Camera). In order to exclude neurological cases of optic nerve edema, a CT scan of the head and orbits was performed. A diagnosis of ODD was made with the aid of ophthalmoscopic and angiographic examinations, orbital ultrasonography, or computed tomographic scanning. ODD were classified on the basis of the appearance of the optic disc, as visible and buried drusen. Patients with a history or evidence on examination of other ocular disease and past intraocular surgery or laser treatment were excluded from the study.

All subjects underwent visual field testing, performed using the Medmont Automated Perimeter and Color Doppler sonography of the ophthalmic artery (OA), the central retinal artery (CRA), and the posterior ciliary arteries (PCA). The blood flow examination was performed using a Siemens Elegra (Germany) unit with 7.5 MHz linear probe. Peak-systolic velocity (PSV), end-diastolic velocity (EDV), and the resistivity index (RI) were measured during the study. The data were compared with age norms established in our ultrasonographic laboratory.

The statistical analysis was performed by SPSS (version 8, PL). Numerical data are shown as mean ± standard deviation (SD). Unpaired t-test was used to compare mean values between the studied groups. Categorical data were analyzed using the Fisher exact test. The difference was considered statistically significant at p value less than 0.05.

Results

Our study group included 28 patients (56 affected eyes) with bilateral drusen and 12 patients (12 affected and 12 unaffected eyes) with unilateral drusen. Of the 68 affected eyes, 38 (56%) were visible and 30 (44%) were buried drusen.

	Affected eyes (n=68)
Asymptomatic	**24 (35%)**
Visual acuity loss	**17 (25%)**
0.9 – 0.7	6 (35%)
0.6 – 0.4	6 (35%)
0.3 – 0.2	3 (18%)
0.1	1 (6%)
0.05	1 (6%)
Visual field loss	**44 (65%)**
Enlargement blind spot	19 (43%)
Nerve fibre bundle	15 (34%)
Generalized constriction	10 (23%)

Tab. I. Visual symptoms in patients with optic disc drusen.
Tab. I. Objawy oczne u pacjentów z druzami nerwu wzrokowego.

Clinical signs were observed in 44 (65%) eyes with drusen. More than one visual symptom was revealed in 17 eyes. All eyes without drusen had normal visual acuity (≥ 1.0). The symptoms are listed in Table I.

There were 21 eyes, including 18 eyes with drusen and 3 without drusen, with a recorded refractive error. Myopia in the range 0.75-3.0 D was present in 7 out of 80 eyes and hyperopia in the range 0.75-4.5 D was detected in 14 out of 80 eyes (Table II). Significant differences in hyperopia were observed between the eyes with and without drusen (p = 0.048). The rate of occurrence of myopia did not differ significantly between the eyes with and without drusen (p = 0.06). There were no significant differences in the occurrence of the refractive error between visible and buried drusen (hyperopia p = 0.156; myopia p = 0.774).

	Emmetropia	Myopia	Hyperopia
Unaffected eyes (n = 12)	9	3	0
Affected eyes (n = 68) (visible/buried)	50 (26/24)	4 (2/2)	14 (10/4)
total	59	7	14

Tab. II. Refractive error in affected and unaffected fellow eyes in patients with optic disc drusen.
Tab. II. Wada refrakcji u pacjentów w oczach z druzami i drugim oku bez druz na tarczy nerwu wzrokowego.

	Affected eyes (n = 68) (visible/ buried)	Unaffected eyes (n = 12)	P values
Spherical equivalent refraction (dioptre)	+0.34 ± 1.03 +0.49 ± 1.24/+0.15 ± 0.65	-0.46 ± 0.89	P = 0.014 P = 0.163
Axial length (mm)	22.80 ± 0.59 22.76 ± 0.69/22.89 ± 0.44	23.36 ± 0.90	P = 0.003 P = 0.515

Tab. III. Comparison of differences in mean values of spherical equivalent refraction and axial length of affected and unaffected fellow eyes in patients with optic disc drusen.
Tab. III. Porównanie różnic średniej wartości sferycznego ekwiwalentu refrakcji i długości osiowej u pacjentów w oczach z druzami i drugim oku bez druz na tarczy nerwu wzrokowego.

	Affected eyes (n = 68)	Unaffected eyes (n = 12)	P values
PSV (cm/ s)	7.6 ± 1.8 (4.0-10.3)	10.4 ± 1.9 (7.8-14.5)	P<0.001
EDV (cm/ s)	2.3 ± 1.1 (0-3.9)	3.4 ± 0.8 (2.3-5.5)	P<0.001
RI	0.71 ± 0.11 (0.58-1.0)	0.64 ± 0.06 (0.54-0.74)	P = 0.047

Tab. IV. Blood flow Doppler parameters in the central retinal artery in affected and unaffected fellow eyes in patients with optic disc drusen.
Tab. IV. Dopplerowskie parametry przepływu w tętnicy środkowej siatkówki u pacjentów w oczach z druzami i drugim oku bez druz na tarczy nerwu wzrokowego.
PSV – peak systolic velocity; EDV – end systolic velocity; RI – resistivity index

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The mean spherical equivalent refraction and axial dimensions of the eye differed significantly among the groups of affected and unaffected eyes. No significant differences were found in eyes with visible and buried drusen in terms of axial length. Although the mean spherical equivalent refraction in eyes with visible drusen was greater than in eyes with buried drusen, the differences were not significant (Table III).

The mean intraocular pressure by applanation examination was 15.51 $\pm$ 2.34 mmHg. We did not observe differences between the IOP height in eyes with and without drusen. Of the 68 affected eyes, only 2 (3%) had colour-deficiency and 3 (4.5%) eyes had an afferent pupillary defect.

The largest blood flow disturbances were found in the central retinal artery. Mean values of peak-systolic and end-diastolic velocities as well as the resistivity index compared between eyes with and without drusen differed statistically (Table IV). We did not observe any statistically significant differences between blood flow Doppler parameters in the ophthalmic artery and short posterior ciliary arteries. Mean values of blood flow parameters in all the examined arteries in the eyes with visible and buried drusen did not differ significantly.

Discussion

In the present study we characterized symptoms and signs associated with optic disc drusen, paid the special attention to biometric and refractive characteristics. We found very interesting dependences in this clinical aspects.

It is commonly known that the refractive error is strongly correlated with the axial length of the eyeball (10). We found that drusen were more frequently associated with hyperopia and smaller eyeballs. However, the literature does not allow these questions to be resolved unequivocally, as the eyeball length in eyes with drusen has not hitherto been examined. Although there are some reports concerning the association between drusen and hyperopia (11), the opinion commonly prevails that the refractive error distribution in eyes with ODD parallels that in the general population (1,12). On the other hand, it has been shown that in patients with drusen, the size of the optic disc and the width of the scleral canal are much smaller as compared to subjects without drusen (4,13,14). Mullie et al. (4) found that these differences could be as much as 20-33%. There are also reports demonstrating that the length of the eyeball is closely associated with the size of the optic disc and the number of fibres in the optic nerve (15,16). With regard to our study, it can be assumed that shorter eyeballs in eyes with drusen are likely to be associated with smaller optic discs and narrower scleral canals. Thus, our results confirm the theory that a narrow scleral canal is one of the risk factors for the development of drusen. Thus, the optic fibres are gathered on a smaller surface and are mechanically compressed, leading to axoplasm transport inhibition and atrophy of retinal ganglionic cell axons (2,3). This theory was challenged by Floyd et al. (17), who did not report any differences between the size of the scleral canal in eyes with and without drusen. However, the authors considered that their results could be connected with distension of the optic nerve by drusen and circumferential displacement of the retinal pigment epithelium and Bruch's membrane. It has also been alleged that the authors did not take into account the race of the subjects examined in their study (18) and as their paper comes from the USA it should be remembered that African-American patients have larger disc areas than Caucasian ones (19).

Lee et al. (20) made the interesting observation that the diameter of retinal vessels was smaller in smaller eyes and smaller optic discs. This results in the blood flow velocity in those vessels, as compared to the retinal central artery and vein of eyes with larger sizes of optic nerve discs. Thus, it is possible that in patients with drusen, whose optic disc size is smaller, blood flow in the retinal vessels may be reduced. However, it should be stressed that disorders of the blood supply to the optic nerve are considered to be one of the pathogenetic mechanisms for the development of visual field defects and reduction of visual acuity in eyes with ODD. Thus, our result of blood flow in the CRA may confirm this theory.

Thought we can not confirm the primary role of biometric and refractive factors in the pathogenesis of ODD, we have demonstrated that some anatomical conditions may contribute to drusen development.

References:

1. Auw-Haedrich C, Staubach F, Witschel H: *Optic disc drusen*. Surv Ophthalmol 2002, 47, 515-532.
2. Spencer WH: *Drusen of the optic disc and aberrant axoplasmatic transport.* The XXXIV Edward Jackson Memorial Lecture. Am J Ophthalmol 1978, 85, 1-12.
3. Tso MO: *Pathology and pathogenesis of drusen of the optic nerve head.* Ophthalmology 1981, 88, 1066-1080.
4. Mullie MA, Sanders MD: *Scleral canal size and optic nerve head drusen*. Am J Ophthalmol 1985, 99, 356-359.
5. Lee AG, Zimmerman MB: *The rate of visual field loss in optic nerve head drusen*. Am J Ophthalmol 2005, 139, 1062-1066.
6. Gonzalez CC, Bueso SE, Valle DD, Frutos RJ, Carretero MM, del Castillo BJM, Sanchez GJ: *Optic nerve drusen and deep visual fields defects.* Arch Soc Esp Oftalmol 2006, 81, 269-274.
7. Bednarczyk-Meller J, Wasilewicz R, Pecold-Stepniewska H, Wasiewicz-Rager J: *OCT and PVEP examination in eyes with visible optic disc drusen.* Klin Monatsbl Augenheilkd 2006, 223, 993-996.
8. Katz BJ, Pomeranz HD: *Visual field defects and retinal nerve fiber layer defects in eyes with buried optic nerve drusen*. Am J Ophthalmol 2006, 141, 248-253.
9. Scholl GB, Song HS, Windkler DE, Wray SH: *The pattern visual evoked potential and pattern electroretinogram in drusen associated optic neuropathy.* Arch Ophthalmol 1992, 110, 75-81.
10. Touzeau O, Allouch C, Borderie V, Kopito R, Laroche L: *Correlation between refraction and ocular biometry.* J Fr Ophthalmol 2003, 26, 355-363.
11. Strassman J, Silverston B, Seelenfreund M, Landau L, Scher A, Berson D: *Optic disc drusen and hypermetropia*. Metab Pediatr Syst Ophthalmol 1991, 14, 59-61.
12. Rosenberg MA, Savino PJ, Glaser JS: *A clinical analysis of pseudopapilledema. I. Population, laterality, acuity, refractive error, ophthalmoscopic characteristics, and coincident disease.* Arch Ophthalmol 1979, 97, 65-70.
13. Jonas JB, Gusek GC, Guggenmoos-Holzmann I, Naumann GO: *Optic nerve head drusen associated with abnormally small optic disc.* Int Ophthalmol 1987, 11, 79-82.
14. Jonas JB: *Biomorphometrie des nervus opticus*. Bücherei des Augenarztes, Enke-Verlag 1989, Stuttgart.

15. Jonas JB, Schmidt AM, Müller-Bergh JA, Schlötzer-Schrehardt UM, Naumann GOH: *Human optic nerve fiber count and optic disc size.* Invest Ophthalmol Vis Sci 1992, 33, 2012-2018.
16. Papastathopoulos KI, Jonas JB, Panda-Jonas S: *Large optic discs in large eyes, small optic discs in small eyes.* Exp Eye Res 1995, 60, 459-462.
17. Floyd MS, Katz BJ, Digre KB: *Measurement of the scleral canal using optical coherent tomography in patients with optic nerve drusen*. Am J Ophthalmol 2005, 139, 664-669.
18. Lee MS: *Scleral canal size in patients with optic disc drusen. Correspondence.* Am J Ophthalmol 2005, 140, 1168-1169.
19. Girkin CA, McGwin G, Xie A, Deleon-Ortega J: *Differences in optic disc topography between black and white normal subject.* Ophthalmology 2005, 112, 33-39.
20. Lee KE, Eden Kobrin Klein B, Klein R Meuer SM: *Association of retinal vessel caliber to optic disc and cup diameters.* Invest Ophthalmol Vis Sci 2007, 48, 63-67.

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