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Optic disk morphometry in high myopia *

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Abstract. The optic nerve head in highly myopic eyes is distinctly different from normal optic disks. We performed magnification-corrected morphometry of photographs of 51 optic nerve heads in highly myopic eyes (myopic refraction of more than −8.00 diopters). Mean refraction was -15.49 ± 5.76 diopters (range, −8.00 to 28.00 diopters), mean age 63.0 ± 12.1 years (range, 27–87 years). The disks were significantly ($P < 0.000001$; Wilcoxon-Mann-Whitney test) larger and more ovally configurated than 457 unselected normal optic nerve heads with a myopic refraction of less than −8.00 diopters. Refraction, size of the disk, and area of the parapapillary region with chorioretinal atrophy were significantly ($P < 0.00001$) correlated with each other. The parapapillary vessel diameter was independent from the disk size. Highly myopic disks can be regarded as secondary acquired macrodisks, the size of which is correlated with refraction and possibly age. They should be differentiated from secondary, acquired macrodisks in congenital glaucoma and from primary macrodisks. As in normal eyes, the parapapillary vessel caliber can be used to estimate the optic disk size in relative and approximately absolute units.

Introduction

Normal and pathologically altered optic nerve heads in eyes with normal ranges of refraction can be differentiated by morphometric characteristics. This can be helpful in diagnosis and interesting in pathogenesis: optic disc drusen, pseudopapilledema, and nonarteritic anterior ischemic optic neuropathy occur more often in small optic nerve heads. The prevalence of optic pits and "morning-glory syndrome" is higher in large optic discs. Glaucomatous optic nerve heads are not significantly different in size from normal, unselected optic nerve heads. For glaucoma diagnosis, morphometry of the intra- and parapapillary structures can help to differentiate between normal eyes with so-called ocular hypertension and those with beginning glaucomatous optic nerve atrophy [2, 4, 7, 10–16, 17, 21–24, 29]. These typical features, however, are not valid in highly myopic eyes where the optic disk has a distinctly different ophthalmoscopic appearance. The purpose of this study was to measure the size and form of the optic disk and of the parapapillary region in highly myopic eyes.

Subjects and methods

Photographs of 51 unselected, normal optic disks were the basis of this study. The mean age of the 18 men and 15 women was 63.0 ± 12.1 years (mean and standard deviation; minimum 27.0 years, maximum 87 years), mean refraction -15.5 ± 5.8 diopters (−8.0 to −28.0 diopters). Eyes with a myopic refraction of less than −8.00 diopters were excluded. All subjects underwent an ophthalmic examination, including refractometry, keratometry, slit-lamp biomicroscopy, gonioscopy, tonometry, and contact lens examination of the fundus. Intraocular pressure ranged between 10 and 21 mm Hg. There was no evidence of any optic nerve disease. No retinal detachment surgery had been performed.

Using a telecentric Zeiss fundus camera, 15° or 30° color photographs of the optic nerve head were taken. Stereo photographs taken sequentially with an Allen stereo separator were also available. We projected the diapositives (10 times magnified), counted the cilioretinal arteries, and plotted the outlines of the disk, the parapapillary vessels, and the parapapillary region with chorioretinal atrophy on paper. These were evaluated morphometrically (Zeiss Morphomat 30).

Concerning the optic disk, we measured the area, the minimal, maximal, horizontal, and vertical diameters, the ratio of the minimal to maximal diameter, and a form factor. The latter ranged between 1.0 for an ideal circle to 0.0 for a structure completely different from a circle. The diameter of the temporal superior or temporal inferior retinal artery and vein were determined at the disk border and 2 mm distant from the optic disk center. Additionally we evaluated the area of the parapapillary region with chorioretinal atrophy. The photographic magnification was corrected according to Littmann [30], taking into account the anterior corneal curvature and the refraction. The lines given in the Littmann diagrams were extrapolated for the myopic refractions of more than −15.0 diopters.

To examine the validity of Littmann's method, the mean area of the optic nerve scleral canal was evaluated postmortem in 107 unselected unfixed human donor eyes. It was compared with the mean area of unselected normal optic

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disks that had been measured intravitally using Littmann's method. No significant difference was found. This can be taken as indirect evidence for the validity of the method [19].

Results

Optic disk

Mean optic disk area was 6.87 ± 3.99 mm^2 (mean and standard deviation) with a minimum of 1.98 mm^2 and a maximum of 19.54 mm^2 (Table 1). It was significantly ($P<0.000001$; Wilcoxon-Mann-Whitney test) larger than the mean area of unselected normal optic nerve heads (2.69 ± 0.70 mm^2) that had been determined in previous studies in series of 100, 300, and 457 optic disks [11, 16, 25, 26]. In these series, normal unselected eyes with a myopic refraction of less than -8.00 diopters had been examined. The optic nerve head form was more oval than in eyes with normal ranges of refraction: the ratio of minimal to maximal diameter and the form factor were significantly ($P<0.000001$ and $P<0.01$; Wilcoxon-Mann-Whitney test) smaller in highly myopic eyes. Additionally, the vertical optic disk axis was more often obliquely orientated.

There were significant ($P<0.00005$) correlations between the disk size and refraction (correlation coefficient, -0.53; slope of the regression line, -0.77; Fig. 1), between the size of the parapapillary region with chorioretinal atrophy and refraction (correlation coefficient, -0.59; slope of the regression line, -0.14), and between the disk size and size of the parapapillary atrophic region (correlation coefficient, 0.80; slope of the regression line, $+0.14$). There was no significant correlation between size of the optic disk and age, and there was also no correlation between refraction and age.

Parapapillary vessel caliber

The diameter of the superior temporal or inferior temporal retinal artery and vein measured at the disk border and 2 mm distant from the disk center were not significantly different from the values found in normal eyes: 0.11 ± 0.04 mm versus 0.113 ± 0.019 mm (artery at the disk border); 0.16 ± 0.06 mm versus 0.149 ± 0.026 mm (vein at the disk border) [27, 28]. As in normal eyes, there was also no significantly correlation with the disk area. The quotient of the vessel diameter divided by the disk area, however, showed a significant correlation ($P<0.00001$) with the disk area (correlation coefficient: -0.64).

Parapapillary chorioretinal atrophy zone

The mean area of the parapapillary chorioretinal atrophy zone was 33.05 ± 23.84 mm^2 (0.00 mm^2 to 60 mm^2 or more). It was significantly correlated with the disk size and refraction.

Cilioretinal arteries

The prevalence of cilioretinal arteries was 9/51 (17.6%). It was not correlated with the refraction, the size of the optic disk, or the area of the parapapillary region with chorioretinal atrophy.

Table 1. Morphometric data of 51 optic disks in highly myopic eyes (< -8.00 diopters)

Disk:	
Area (mm^2)	6.87 ± 3.99
Diameter (mm)	
Horizontal	2.90 ± 0.67
Vertical	3.28 ± 1.00
Minimal	2.49 ± 0.70
Maximal	3.18 ± 1.01
Minimal/maximal diameter	0.80 ± 0.12
Form factor	0.94 ± 0.05
Angle between maximal diameter and the horizontal (degree)	83.7 ± 43.5
Parapapillary vessel diameter (mm)	
Artery (disk border)	0.11 ± 0.04
Artery (2 mm from the disk center)	0.12 ± 0.04
Vein (disk border)	0.16 ± 0.06
Vein (2 mm from the disk center)	0.18 ± 0.05
Parapapillary chorioretinal atrophy zone (mm^2)	33.05 ± 23.84

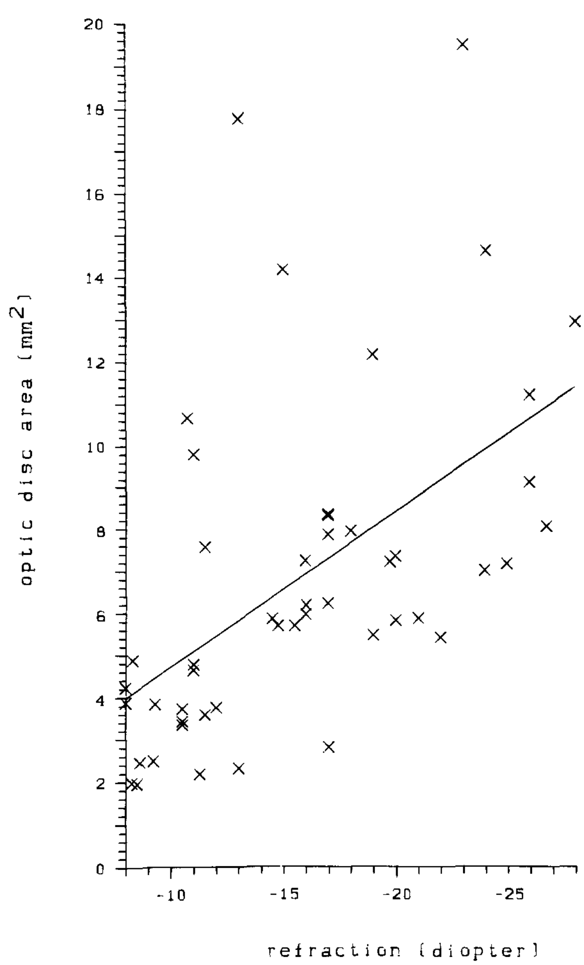

Fig. 1. Scattergram of refraction to disk size in 51 highly myopic eyes (myopic refraction more than -8.00 diopters)

Discussion

Optic disk

The optic nerve head size is not interindividually constant [3, 9]. In previous studies [15, 20, 25, 26], the area of unselected, normal optic disks ranged between 0.86 mm^2 and

5.54 mm^2, indicating an interindividual variability of 1:6.4. The largest optic nerve heads measured so far are those with „morning-glory-syndrome" (7.47 ± 2.63 mm^2) [29] and with optic disk pits (4.84 ± 1.42 mm^2) [21]. These optic nerve heads have been defined as macrodisks because their area is larger than the mean value of unselected normal optic nerve heads (2.69 mm^2) plus two standard deviations (2 × 0.70 mm^2). According to the Gaussian distribution curve, only 2.28% of all disks can be expected beyond this limit.

The morphometric definition of macrodisks is also fulfilled by the highly myopic optic nerve heads: their mean area (6.87 ± 3.99 mm^2) was significantly larger ($P <$ 0.000001) than the mean standard value and exceeded the limit of macrodisks (4.10 mm^2).

In contrast to the normal optic nerve heads, the highly myopic disks were correlated with the refraction: the more myopic the eye, the larger the disk. No correlation existed in this study between the refraction and age; the youngest subject was 27 years old. Considering, however, that the myopic refraction normally increases with age, and regarding the correlation between refraction and disk size, it may be hypothesized that besides the refraction, the disk size also becomes larger in older, highly myopic subjects. The optic nerve head in highly myopic eyes might possibly thus be regarded as secondary, acquired macrodisks, the size of which increases with refraction.

The only other entity known so far with secondary, acquired macrodisks is congenital glaucoma where a pressure-induced disk and cup enlargement have been shown [32]. Regarding the scattergram of refraction and disk area, it may be concluded further that each diopter increase in refraction may be accompanied by an enlargement of the optic disk, on average by 0.77 mm^2, according to the slope of the regression line (Fig. 1).

Parapapillary region with chorioretinal atrophy

Not only the disk area but also the size of the parapapillary region with chorioretinal atrophy was distinctly correlated with the refraction: the more myopic the eye and the larger the optic disk, the larger the parapapillary atrophic region. This is in contrast to parapapillary chorio-pigmentepithelioretinal atrophy in glaucoma, the size of which is correlated to the glaucoma-associated alterations within the optic disk and to visual field loss [21, 22].

Parapapillary retinal vessel diameter

The caliber of the retinal superior temporal or inferior temporal artery and vein in highly myopic eyes was not significantly different compared with eyes with normal ranges of refraction. As in normal eyes the vessel diameter was not but the ratio of vessel diameter divided by disk area was correlated to the disk size. Thus, the parapapillary vessel diameter in highly myopic eyes can be used to estimate the disk size in relative and approximately absolute size units. Care must be taken, however, in glaucomatous eyes in which a glaucoma-associated reduction of the vessel caliber has been shown [27, 28].

Cilioretinal arteries

The prevalence of cilioretinal arteries found in the highly myopic eyes in this study (17.6%) fits the results of previously reported examinations [8, 31]. In eyes with normal ranges of refraction, a correlation between the number of the cilioretinal arteries and the disk size has been shown [18, 24]. This, however, was not found in highly myopic eyes. It is hypothesized that in highly myopic eyes before myopic enlargement of the globe and optic disk, this correlation exists, but that it becomes insignificant with myopic enlargement.

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