# Use of macular thickness parameters for the diagnosis of primary open-angle glaucoma

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### Abstract

**Introduction:** Retinal thickness in primary open-angle glaucoma patients was determined to establish its correlation with advancement of glaucoma neuropathy.

**Material and methods:** One hundred ninety-four patients (371 eyes, age 30–65 years) were divided in 3 groups including 50 patients with confirmed primary open-angle glaucoma, 67 primary open-angle glaucoma-suspected patients and 77 healthy persons (control group). The retinal foveola, foveal, peri-foveal and posterior pole average thickness values were determined with an RTA analyzer. For comparison, linear cup-to-disc diameter ratio (C/D), nerve fiber index (NFI) and mean defect of the retina sensitivity (MD) were also determined.

**Results:** Statistically highly significant differences in the retinal thickness and glaucoma parameters between the individual groups were observed. In the peri-foveal region, the retinal thickness in glaucoma patients was only 173.0 ±11.4 µm while in the healthy patients 201.1 ±13.1 µm. In the posterior pole region, the thickness values were only 168.1 ±11.3 µm and 195.7 ±12.3 µm, respectively. A moderate correlation between retinal thickness in peri-foveal and posterior pole regions and the C/D, NFI and MD parameters was also established (Pearson coefficients below –0.351 or above 0.284).

**Conclusions:** The retinal thickness in the peri-foveal and posterior pole regions depends on the degree of glaucoma advancement. This original observation may be a basis for acceptance of this method as a quite new tool in glaucoma diagnosis.

**Key words:** primary open angle glaucoma, retinal thickness, macula, retinal thickness analyzer, retinal thickness analysis.

## Introduction

Modern diagnosis of primary open-angle glaucoma consists in evaluation of the optic disc, neuroretinal rim and retinal nerve fiber layer by indirect stereoscopic observation using the slit lamp and Volk lens [1]. This examination depends on physician experience and can be hardly used because of high variability of optic nerve head structure. Nowadays, laser-scanning ophthalmoscopy (HRT) and laser scanning polarimetry (GDx) are commonly used additional diagnostic methods. The methods are very useful in the early stage of glaucoma; however, direct ophthalmologic examination still remains the basic tool, because results achieved by modern methods are often inefficient for glaucoma diagnosis. This is why other diagnostic methods are also necessary.

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Retinal thickness analysis (RTA) is a new method in glaucoma diagnosis and has not been used till now. It seems that measurements performed in the perifoveal region can also be sensitive and reliable enough, because the anatomic structure of the scleral channel of the optic nerve does not affect the architecture of the nerve fiber and ganglion cell layers. Changes in the retinal thickness in the macular region can deliver indirect information on atrophy of ganglion cells and nerve fibers [2–4].

The aim of the study was to determine the retinal thickness in primary open-angle glaucoma patients, primary open-angle glaucoma-suspected patients and in healthy persons using the retinal thickness analyzer (RTA) and to establish the correlation between retinal thickness in the macular region and the advancement of glaucoma neuropathy as determined using the linear cup-to-disc diameter ratio (C/D), nerve fiber index (NFI) and mean defect (MD) parameters.

## Material and methods

One hundred ninety-four patients (371 eyes, age 30–65 years) who presented in 2007–2009 at the Department of Ophthalmology of the Medical Centre for Postgraduate Education (CMKP) in Warsaw were included in the study. The patients were divided into 3 groups. Group A consisted of 50 glaucoma patients (95 eyes, average age 43.7 ±9.0 years) with confirmed primary open-angle glaucoma. Group B consisted of 67 primary open-angle glaucoma-suspected patients (128 eyes, average age 43.2 ±11.0 years) without any changes in the visual field. The control group C consisted of 77 healthy persons (148 eyes, average age 46.3 ±10.9 years). The patients were qualified for the particular groups according to directions of the European Glaucoma Society [1] earlier described in detail [5–7]. Characteristics of the studied population are given in Table I.

All patients underwent full ophthalmologic examination. The retinal thickness was determined using the RTA analyzer (Talia Technology Ltd., Israel) after mydriasis with 1% tropicamide solution. In all groups, foveola average thickness (VAV), foveal average thickness (FAV), peri-foveal average thickness (PFAV) and posterior pole average thickness (PPAV) were determined. Linear cup-to-disc diameter ratio (C/D) was determined using a HRT II laser-scanning ophthalmoscope (Heidelberg retina tomograph) made by Heidelberg Engineering. Nerve fiber index was determined using a GDx VCC laser-scanning polarimeter (glaucoma diagnostics with variable corneal compensation) made by Laser Diagnostic Technologies. Mean defect of the retina sensitivity (MD) was determined during visual field examination using frequency doubling technology (FDT). The ophthalmologic

examinations and RTA studies were performed in the Ophthalmology Department of the CMKP. The GDx, HRT and FDT studies were carried out at the Institute of Glaucoma and Eye Diseases in Warsaw.

The project received permission from the Bioethics Commission of CMKP on 30 January 2008. The patients were informed of the aim and course of the study and agreed to take part in the project.

## Statistical analysis

The data were statistically evaluated. The significance of differences between the mean values of retinal thickness in the particular regions and mean values of C/D, NFI and MD in particular groups was evaluated using Student's t test. Power of the correlations of VAV, FAV, PFAV and PPAV with C/D, NFI and MD were described with linear Pearson correlation coefficient [8, 9].

## Results

Retinal thickness data in particular regions (VAV, FAV, PFAV and PPAV) for the patients in groups A, B, and C are presented in Table II. The data concerning C/D, NFI and MD parameters for the patients in groups A, B, and C are presented in Table III. In Table IV, linear Pearson correlation coefficients are presented to describe power of the correlations of VAV, FAV, PFAV and PPAV with C/D, NFI and MD. In Table V, linear Pearson correlation coefficients of C/D, NFI and MD are presented for comparison purposes.

The correlations between retinal thickness in particular regions and C/D, NFI and MD parameters in the whole population (A, B, and C groups) are presented in Figures 1–3.

## Discussion

The studied population (Table I) was selected according to directives of the European Glaucoma Society [1] and the individual groups A, B, and C showed comparable sizes and age of the patients included.

Retinal thickness in glaucoma patients and healthy persons, presented in Table II, can be

**Table I.** The studied population (groups A, B and C) according to sex, number of persons (number of eyes)

| Group | Gender | | Total |
| --- | --- | --- | --- |
| | Male | Female | |
| A | 27 (51) | 23 (44) | 50 (95) |
| B | 21 (40) | 46 (88) | 67 (128) |
| C | 14 (27) | 63 (121) | 77 (148) |
| Total | 62 (118) | 132 (253) | 194 (371) |

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**Table II.** Results of determination of retinal thickness in particular VAV, FAV, PFAV and PPAV regions in groups A, B and C [μm]

|  | VAV | FAV | PFAV | PPAV |
|---|---|---|---|---|
| **Group A** | | | | |
| Mean value | 139.0 | 149.9 | 173.0 | 168.1 |
| Standard deviation | 20.5 | 17.4 | 11.4 | 11.3 |
| **Group B** | | | | |
| Mean value | 147.6 | 157.1 | 187.3 | 182.5 |
| Standard deviation | 21.2 | 18.6 | 15.6 | 14.8 |
| **Group C (control)** | | | | |
| Mean value | 160.9 | 171.2 | 201.0 | 195.7 |
| Standard deviation | 21.4 | 19.8 | 13.1 | 12.3 |

**Table III.** Results of determination of C/D, NFI and MD parameters in groups A, B and C

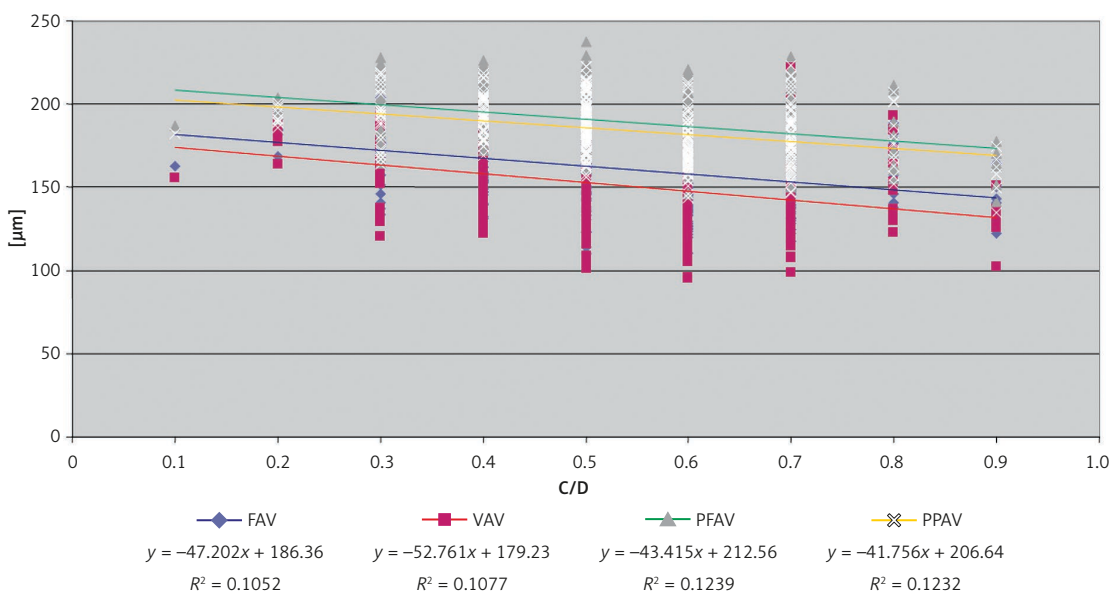|  | C/D | NFI | MD |
|---|---|---|---|
| **Group A** | | | |
| Mean value | 0.65 | 37.0 | −3.00 |
| Standard deviation | 0.11 | 22.7 | 5.07 |
| **Group B** | | | |
| Mean value | 0.58 | 18.5 | −0.77 |
| Standard deviation | 0.11 | 5.6 | 2.49 |
| **Group C (control)** | | | |
| Mean value | 0.43 | 15.1 | −0.29 |
| Standard deviation | 0.11 | 4.8 | 1.94 |

**Table IV.** Pearson correlation coefficients between retinal thickness in particular regions and the C/D, NFI and MD parameters in the whole population (groups A, B and C)

| Parameter | VAV | FAV | PFAV | PPAV |
|---|---|---|---|---|
| C/D | −0.328 (moderate) | −0.324 (moderate) | −0.352 (moderate) | −0.351 (moderate) |
| NFI | −0.109 (weak) | −0.099 (minute) | −0.351 (moderate) | −0.355 (moderate) |
| MD | 0.131 (weak) | 0.119 (weak) | 0.289 (moderate) | 0.284 (moderate) |

**Table V.** Pearson correlation coefficients between the NFI, C/D and MD parameters in the whole population (groups A, B and C)

|  | C/D | MD |
|---|---|---|
| NFI | 0.481 (moderate) | −0.400 (moderate) |
| C/D |  | −0.400 (moderate) |

partly compared with the respective literature data. According to the available sources, the average fovea retinal thickness in the healthy persons was 167 μm [10], 16.0 ±23.0 μm [11], 168.57 ±22.27 μm [12] and 178 ±44 μm [13]. The posterior pole average thickness was 229 μm [10], 171.9 ±25.3 μm [14], 175 ±14 μm [15], 177.77 ±26.13 μm [16] and 211.4 ±168 μm [4] in the same group. The measured and literature data



FAV   $y = -47.202x + 186.36$   $R^2 = 0.1052$
VAV   $y = -52.761x + 179.23$   $R^2 = 0.1077$
PFAV   $y = -43.415x + 212.56$   $R^2 = 0.1239$
PPAV   $y = -41.756x + 206.64$   $R^2 = 0.1232$

**Figure 1.** Correlations between retinal thickness in particular regions and the C/D parameter in the whole population (groups A, B and C)
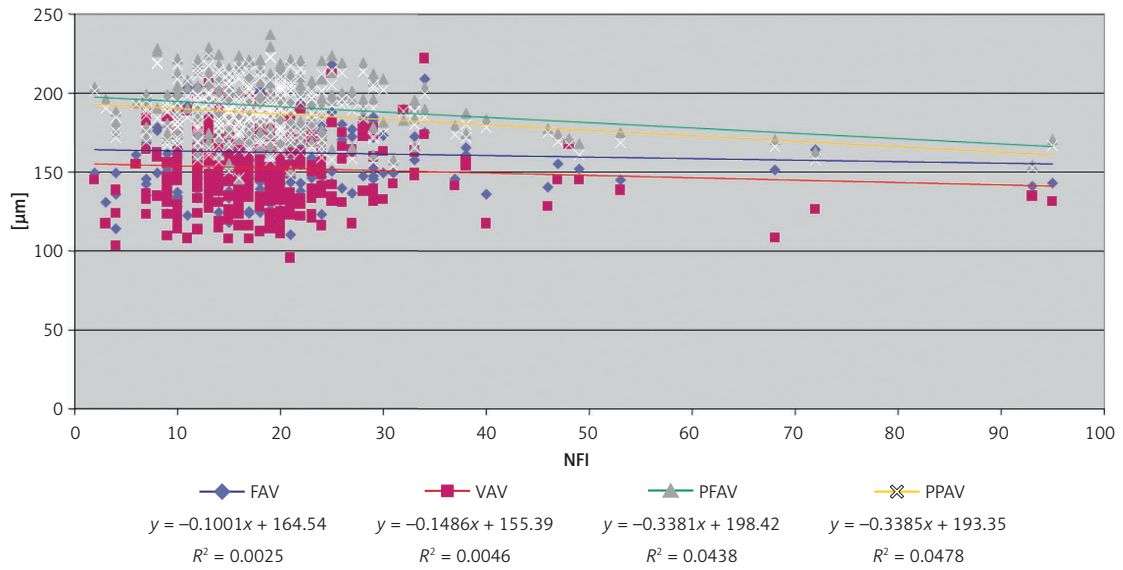
**Figure 2.** Correlations between retinal thickness in particular regions and the NFI parameter in the whole population (groups A, B and C)
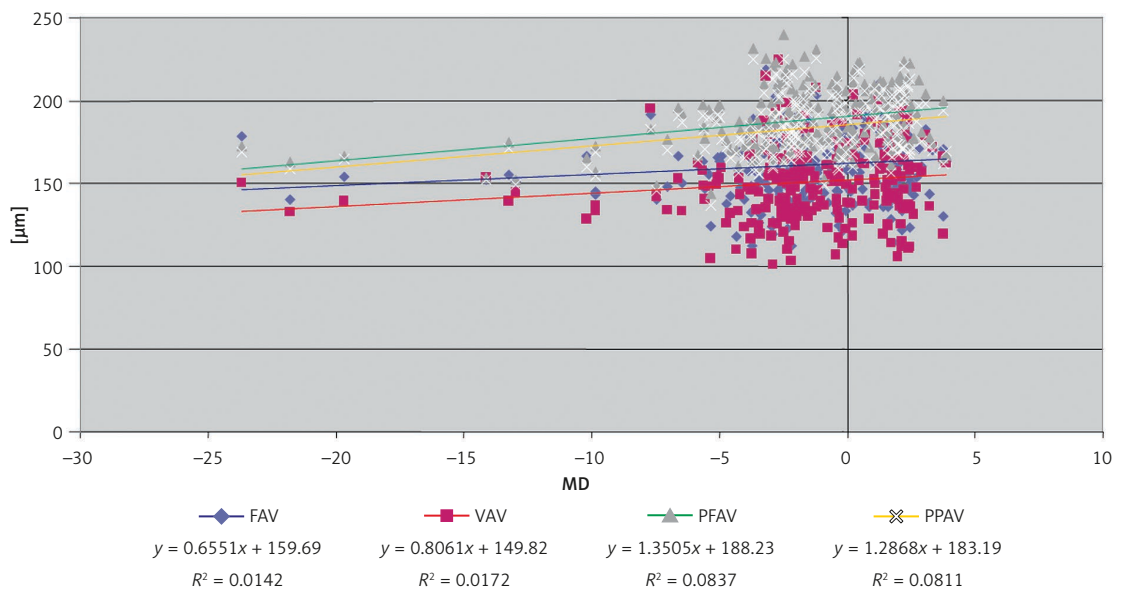


**Figure 3.** Correlations between retinal thickness in particular regions and the MD parameter in the whole population (groups A, B and C)

are comparable though they show quite high dispersion.

There are available only limited data on the retinal thickness in glaucoma patients. Zeimer *et al.* [2] examined 18 primary open-angle glaucoma patients but described only 5 of them. The patients also showed a decreased retinal thickness. Similarly, Brusini *et al.* [3] observed a decrease in retinal thickness in glaucoma patients. Tanito *et al.* [4] determined the retinal thickness in the perifoveal region as 185.7 ±16.8 μm while Zhikuan and Du Shuhua [16] found 152.21 ±25.54 μm. The values differ not only one from another but also from the mea-

sured data (Table II). Similarly, limited data are available for glaucoma-suspected patients. Only Tanito *et al.* [4] have determined the perifoveal retinal thickness: 190.4 ±15.6 μm. This value is very close to the value measured in the present study.

The retinal thickness values in particular groups differed significantly and can be successfully applied in early diagnosis of primary open-angle glaucoma, especially for studying perifoveal and posterior pole regions, where the thinning effects were of a large extent.

The C/D values (Table III) showed, according to common expectations, very large differences be-

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tween particular groups but they can be hardly used for differentiation between groups A and B, because of relatively small differences. The NFI values also differ significantly between the individual groups. According to the data published by da Pozzo *et al.* [17], the NFI index in healthy persons was lower than 18, while in glaucoma patients it exceeds 31. This agrees with the data measured in the present study. The diagnostic value of the NFI index was also confirmed by Reus and Lemi [18], Zheng *et al.* [19] and Medeiros *et al.* [20]. Also, the MD value differed significantly between healthy persons and glaucoma patients. The measured MD values were close to literature data. For example, Bowd *et al.* [21] found MD –0.16 dB for healthy persons and MD –3.8 dB for glaucoma patients. Boden *et al.* [22] found MD –2.9 dB, and Racette [23] MD –3.69 dB for glaucoma patients. The literature data agree well with the present data also in this area.

The strongest correlation between retinal thickness and C/D (Figure 1), MD (Figure 2) and NFI (Figure 3) parameters was observed in perifoveal and posterior pole regions. In all cases, a decreased retinal thickness was established with increasing values of the C/D, MD and NFI parameters (Figures 1–3). The comparison of the linear Pearson correlation coefficients (Table IV) between retinal thickness in particular regions and C/D, NFI and MD parameters allows for confirmation of substantial relationships between the peri-foveal and posterior-pole retinal thickness and the advancement of glaucoma. There are no data in the literature on this subject. Only Zeimer *et al.* [2], Tanito *et al.* [4], Cvenkel *et al.* [24] and Brusini *et al.* [3] have observed a connection between the decrease in retinal sensitivity and decrease in retinal thickness in the macular area.

The correlation coefficients between the accepted diagnostic methods (NFI, C/D, MD) are low (Table V), which can be explained by high dispersion of the determined values. Therefore, the low values of correlation coefficients between C/D, NFI, MD and retinal thickness in particular areas (Table IV) are not surprising and do not bring any proof against the retinal thickness analysis.

In conclusion, there is a close relationship between retinal thickness in the macular area and occurrence of glaucoma neuropathy. The retina in the macular region is significantly thinner in primary open-angle glaucoma than in primary open-angle glaucoma-suspected patients and healthy persons.

There is a moderate correlation between retinal thickness in peri-foveal and posterior pole regions and C/D, NFI and MD parameters. The retinal thickness in these regions depends on the degree of glaucoma advancement.

Retinal thickness analysis has not been commonly used for glaucoma diagnosis yet. The measurements carried out in perifoveal and posterior pole regions show a high reproducibility and low standard deviation. This original observation is a basis for acceptance of this method as a quite new tool in glaucoma diagnosis [7].

## Acknowledgments

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