The Foveal Position Relative to the Optic Disc and the Retinal Nerve Fiber Layer Thickness Profile in Myopia

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PURPOSE. To evaluate retinal nerve fiber layer (RNFL) thickness profiles according to the foveal position relative to the optic disc in myopia

METHODS. In 164 eyes of 164 healthy myopic subjects, the disc-foveal angle was defined as the angle between a horizontal line through the disc center and the line connecting the fovea and disc center in fundus photographs overlaid on Cirrus-HD optical coherence tomography (OCT) images. The quadrant/clock-hour based peripapillary RNFL thickness and differences between the inferior and superior (I-S) quadrant RNFL thicknesses were measured with OCT. RNFL thickness profiles were determined according to the disc-foveal angle and axial length (AL).

RESULTS. As the disc-foveal angle increased (i.e., the fovea becomes more inferior to the optic disc), the superior RNFL decreased significantly (P = 0.003), whereas the inferior RNFL and I-S difference increased (P = 0.010 and P < 0.001, respectively). As the AL increased, the average and temporal RNFLs increased significantly (P = 0.013 and P < 0.001, respectively), and I-S difference was not affected (P = 0.251). The disc-foveal angle was significantly decreased with the distance between the fovea and the optic disc (P = 0.035). In multiple linear regression analysis, the disc-foveal angle was found to be a significant factor related to I-S differences, superior and inferior RNFL (all, P < 0.05) after adjusting for age, disc area, and AL.

CONCLUSIONS. The intrinsic foveal position relative to the optic disc was an essential determinant of normal RNFL thickness in myopia. In particular, it was associated with the vertical asymmetry of RNFL distribution.

Keywords: disc-foveal angle, retinal nerve fiber layer, RNFL distribution, myopia

Knowledge of the normal retinal nerve fiber layer (RNFL) thickness profile is important because an evaluation of RNFL thickness is crucial in detecting and following glaucoma patients.1 New imaging devices such as optical coherence tomography (OCT) using Fourier/spectral domain technology enable precise measurements of the RNFL thickness with good sensitivity and specificity for the detection of glaucomatous damage.2 However, considerable variation in the RNFL thickness profile exists in the normal population.3,4 Known factors determining normal RNFL distribution are age, ethnicity, axial length (AL), and optic disc area.5

Another issue is that the fovea is normally positioned below the optic nerve head, which might cause asymmetry in the distribution of the RNFL between the superior and inferior retina.6,7 The fovea is located 6.3° ± 3.0° vertically below the optic disc in healthy individuals, and considerable interindividual variation exists in the range of the normal disc-foveal angle.8–11 This anatomical variation in the relative foveal position among individuals is considered one of the sources of variability in the structure-function correspondence in glaucomatous eyes.12,13 In this regard, it is believed that the foveal position relative to the optic disc affects the RNFL distribution. However, the normal RNFL thickness profiles associated with the foveal position relative to the optic disc have not yet been elucidated.

Myopia is an increasing public health concern due to its high prevalence and increasing severity, particularly among the Asian population.14 During myopic axial elongation, the posterior sclera undergoes dynamic changes which are reflected in the posterior pole parameters (i.e., optic disc morphology, peripapillary atrophy (PPA), and the position of fovea in relationship to the optic disc), as shown in previous studies.15,16 Therefore, it is important to evaluate the effect of the relative foveal position on RNFL distribution in relationship to the AL because myopia also affects the normal RNFL distribution.

Therefore, this study investigated the clinical characteristics and RNFL thickness profiles associated with the intrinsic foveal position relative to the optic disc in a healthy myopic population.

MATERIALS AND METHODS

Study Samples

The medical records of all consecutive patients with myopia who underwent preoperative examination for refractive...
Disc-Foveal Angle and RNFL Thickness

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surgery (LASIK or surface ablation, including laser epithelial keratomileusis [LASEK], epi-LASIK, or phakic intraocular lens insertion), between September and October, 2012 at the B & VIIT Eye Center, Republic of Korea, patient charts were reviewed retrospectively. This study was performed according to the tenets of the Declaration of Helsinki, and the study protocol was approved by the institutional review/ethics boards of the Catholic University, Seoul St. Mary’s Hospital.

All subjects underwent a full ophthalmic examination, which included measuring the visual acuity (VA) and refraction, the intraocular pressure (IOP) using Goldmann applanation tonometry. AI, using laser interference biometry (IOL Master; Carl Zeiss Meditec, Dublin, California), a dilated fundus examination, stereosdisc photometry, and retinal photography using digital retinal cameras (CR-1 Mark II; Cannon, Tokyo, Japan) after maximum pupil dilatation and standard perimetry (24-2 Swedish interactive threshold algorithm, SAP Humphrey field analyzer II; Carl Zeiss Meditec) and OCT (Cirrus high-definition [HD]-OCT; Carl Zeiss Meditec).

Inclusion criteria were a healthy optic nerve head without glaucomatous damage (i.e., no disc hemorrhage, thinning, or neural rim notching) and absence of any glaucomatous visual field (VF) defects. A glaucomatous VF change was defined as the consistent presence of a cluster of 5 or more points on the pattern deviation plot with a probability of occurring in <1% of the normal population or as having 1 point with the probability of occurring in <5% of the normal population and glaucoma hemifield test results outside the normal limits or a pattern standard deviation P of <5%.17

To rule out eyes with pathologic myopia, eyes with spherical equivalent less than −8.0 diopter (D) and pathologic retinal lesions, such as a lacquer crack, or Fuchs’ spot, were excluded. Eyes with concurrent disease other than refractive error, with a best-corrected VA < 20/20, an IOP > 21 mm Hg in either eye; a history of severe ocular trauma, intraocular or refractive surgery, or evidence of diabetic retinopathy; diabetic macular edema or other vitreoretinal disease in either eye; evidence of optic nerve or RNFL abnormality in either eye; media opacity, or a closed or occludable angle were also excluded. When both eyes were eligible, 1 eye was selected randomly for inclusion in the study.

Measurements of Disc–Foveal Angle, Optic Disc Tilt, Peripapillary Atrophy, and Distance From the Fovea to the Disc Center

Color retinal photographs were obtained using standard settings on a nonmydriatic retinal camera (Cannon). The subjects were seated at the fundus camera with their chin in the chin rest and forehead against the forehead rest. The subjects’ eyes were aligned with the eye level mark on the forehead rest support by raising or lowering the chin rest. They were instructed to hold their heads in a vertical position throughout the photographic session. Using the eye to be photographed, each patient was instructed to look directly at the internal fixation target in the fundus camera, which was used as a maker for the foveal center.

Retinal photographs were evaluated independently and in random order and masked fashion, without knowledge of the clinical information by two of the authors (JAC and HYP). Optic disc tilt, the distance from the fovea to the disc center, was measured from the photographs using ImageJ version 1.40 software (National Institutes of Health, Bethesda, Maryland; http://rsb.info.nih.gov/ij/index.html). The average values of 2 authors were used. Optic disc tilt was determined using the tilt ratio, defined as the minimum-to-maximum disc diameter ratio, as previously described.18 To characterize changes in the posterior pole in association with axial scleral elongation, we measured the distance from the fovea to the disc center, which was defined as the point at which the minimum and maximum diameter lines met on fundus photographs.14

Finally, to quantify the position of the fovea relative to the optic disc, the disc–foveal angle was measured. To compensate for the potential errors induced by ocular rotation, the fundus photographs were manually registered to enface HD-OCT images (RNFL deviation map) with Illustrator CS4 software (Adobe Systems Inc., San Jose, California), as previously described with some modification.19 The RNFL deviation map, provided in Cirrus HD-OCT RNFL and ONH (optic nerve head) analysis report, shows an OCT en face fundus image (Fig. 1A), which shows boundaries of the cup and disc, as well as the center of the disc, based on the margin of Bruch’s membrane (Fig. 1A, red arrowhead). After transparency of the fundus photographs was set to 60% to allow visualization of the underlying en face image, precise image overlays were made using retinal vessels as guidelines. Based on the overlaid images, the disc–foveal angle was defined as the angle between the OCT-defined disc center and fovea measured as the angle between the reference line and horizontal meridian of the optic disc (Fig. 1C).8,10,11,20 A positive value indicated that the fovea was located inferior to the optic disc, and a negative value indicated that the fovea was superior to the optic disc.

RNFL Measurement by OCT

A commercial spectral domain OCT device was used in this study. Imaging was performed using an optic cube scan consisting of 200 × 200 axial scans (pixels) of the optic nerve region. Image quality was assessed by an experienced examiner blinded to patient identity and other test results. Only well-focused, well-centered images without eye movement and a signal strength of ≥7 were used. The average and mean RNFL thicknesses in each quadrant (superior, temporal, inferior, and nasal) and 12-hour clock-face RNFL thicknesses were determined for all individuals and subjected to analysis. In addition, the differences between the inferior (I) and superior (S) RNFL thicknesses were designated IS difference and calculated as inferior quadrant RNFL thickness – superior quadrant RNFL thickness.

Adjusting for Ocular Magnification

To correct axial length-related ocular magnification, we relied on the Littmann formula (\( t = p \times q \times s \),21 as modified by Bennet.22 In the formula, \( t \) is the actual fundus size, \( s \) is the size measured on fundus photography, \( p \) is the magnification factor related to the camera, and \( q \) is the magnification factor related to the eye. The correction factor \( q \) can be determined with the formula \( q = 0.01306 (x - 1.82) \), where \( x \) is the AL.

The term \( p \) is instrument-dependent and remains a constant in a telecentric imaging system. To analyze posterior pole parameters such as the distance from the fovea to the disc center and PPA, we calculated the magnification factor of the digital retina camera by referring to a previous study on measurements obtained with fundus photographs and determined the actual fundus size.23 As shown in previous studies,14,24,25 both the RNFL peripapillary scan circle and the optic disc area are related to camera magnification in the fundus imaging system (\( p \)) and the optical dimension of the given eye (\( q \)). Therefore, we used the known magnification factor of 3.382 for the analysis of HD-OCT posterior disc (average/quadrant RNFL thickness), which is the same calculated value as that used for the Stratus OCT (Carl Zeiss Meditec) system (i.e., actual average RNFL thickness in a

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showed normal distributions upon Shapiro-Wilk normality testing (P = 0.128). The measurement of disc-foveal angle showed excellent interobserver (CJA and PHY) and intervisit reproducibility. ICC, 0.965 (95% confidence interval: 0.927–0.984) and ICC 0.933 (95% confidence interval: 0.864–0.935), respectively.

To characterize the disc-foveal angle, we compared the ocular variables between eyes with a greater disc-foveal angle (≥0.63°; indicating a more inferior foveal position relative to the optic disc) and those with a lesser disc-foveal angle (<0.63°; indicating a foveal position more parallel to the optic disc) (Table 1). In eyes with a greater disc-foveal angle, the superior RNFL was marginally thinner (P = 0.087), whereas the inferior RNFL was thicker in eyes with a greater disc-foveal angle than in eyes with a lesser disc-foveal angle (P = 0.041). The I-S difference differed significantly between groups, with an inverted value in eyes with a lesser disc-foveal angle (P = 0.002). In the OCT profiles of the 164 participants, the superior RNFL decreased significantly (r = −0.224, P = 0.005), and the inferior RNFL and I-S differences increased significantly (r = 0.196, P = 0.010; r = 0.336, P < 0.001) with an increase in the disc-foveal angle (Fig. 3).

The linear regression analysis of disc-foveal angle and clock-hour-based RNFL thickness showed that RNFL thicknesses from 7 to 1 o’clock decreased (statistical significance at 8 and 12 o’clock; P = 0.016 and P < 0.001, respectively), and RNFL thicknesses from 2 to 6 o’clock increased (statistical signifi-

FIGURE 1. Determination of disc-foveal angle using the overlay images of fundus photographs and SD-OCT images. (A) The RNFL deviation map, provided in Cirrus HD-OCT RNFL and ONH analysis report, shows OCT en face fundus image, which shows boundaries of the cup (red line) and disc (black line), as well as the center of the disc (red arrowhead), based on the margin of Bruch’s membrane (B) Fundus photographs are shown. (C) After transparency of the fundus photographs was set to 60% to allow visualization of the underlying en face image, precise overlay images were made using retinal vessels as guidelines. Based on the overlay images, the disc-foveal angle was measured, defined as the angle between a horizontal line through the disc center and the line connecting the fovea and disc center.

FIGURE 2. Frequency distribution of the disc-foveal angle in the eyes of the participants (n = 164). Data had a normal distribution according to the Shapiro-Wilk normality test. Most values were positive.
cance at 5 and 6 o’clock; $P = 0.002$ and $P = 0.008$, respectively) with an increase in the disc–foveal angle (Table 2).

In terms of AL, the average and temporal RNFL increased significantly ($r = 0.194$, $r^2 = 0.038$, $P = 0.013$; and $r = 0.408$, $r^2 = 0.161$, $P < 0.001$, respectively), while the I-S difference was not associated with AL ($r = -0.094$, $r^2 = 0.003$, $P = 0.231$) (Fig. 4).

The distance from the fovea to the disc center was increased with AL and disc tilt ($r = 0.155$, $P = 0.041$; and $r = 0.336$, $P < 0.001$, respectively). The disc–foveal angle decreased significantly with the distance from the fovea to the disc center ($r = -0.161$, $P = 0.033$).

After multiple linear regression analysis, the disc–foveal angle was found to be the significant factor related to the I-S difference ($P < 0.001$) after controlling for age, disc area, and AL. The disc–foveal angle also significantly affected the superior and inferior quadrant RNFL thickness ($P = 0.004$ and $P = 0.004$, respectively). Regarding temporal quadrant RNFL thickness, AL was found to be a significant determinant after multiple linear regression analysis ($P < 0.001$) (Table 3).

**DISCUSSION**

This study demonstrated that the foveal position relative to the optic disc was a significant determinant of the RNFL distribution in healthy myopic subjects (Table 3 and Fig. 5). Whereas AL particularly affected the temporal-side RNFL, the relative foveal position was associated with the vertical asymmetry of RNFL distribution. The disc–foveal angle was also affected by the distance between the fovea and the disc center. There is a wide range of normal RNFL thickness variation, which is affected by age, ethnicity, AL, and optic disc area. To the best of our knowledge, this is the first study to characterize the relative foveal position as a significant determinant of the normal RNFL distribution in relation to other known determinant factors.

**TABLE 1. Posterior Pole Characteristics of Subgroups Classified by Disc–Foveal Angle**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Greater Disc–Foveal Angle ($\geq 6.03^\circ$)</th>
<th>Lesser Disc–Foveal Angle ($&lt; 6.03^\circ$)</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of participants</td>
<td>82</td>
<td>82</td>
<td></td>
</tr>
<tr>
<td>Disc–foveal angle</td>
<td>8.83 ± 2.23</td>
<td>3.28 ± 1.92</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Spherical equivalent, D</td>
<td>$-5.16 \pm 2.22$</td>
<td>$-4.68 \pm 2.82$</td>
<td>0.218</td>
</tr>
<tr>
<td>Axial length, mm</td>
<td>25.68 ± 1.13</td>
<td>25.59 ± 1.22</td>
<td>0.589</td>
</tr>
<tr>
<td>Distance from fovea to disc center, mm</td>
<td>6.36 ± 0.37</td>
<td>6.44 ± 0.41</td>
<td>0.153</td>
</tr>
<tr>
<td>Optic disc area, mm$^2$</td>
<td>1.94 ± 0.40</td>
<td>2.00 ± 0.35</td>
<td>0.298</td>
</tr>
<tr>
<td>RNFL profiles</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average RNFL thickness, μm</td>
<td>98.86 ± 8.04</td>
<td>98.50 ± 9.29</td>
<td>0.783</td>
</tr>
<tr>
<td>Quadrant analysis, μm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Superior</td>
<td>120.08 ± 14.39</td>
<td>123.82 ± 14.34</td>
<td>0.087</td>
</tr>
<tr>
<td>Nasal</td>
<td>65.00 ± 10.31</td>
<td>66.62 ± 12.84</td>
<td>0.361</td>
</tr>
<tr>
<td>Inferior</td>
<td>125.98 ± 15.31</td>
<td>120.94 ± 16.95</td>
<td>0.041</td>
</tr>
<tr>
<td>Temporal</td>
<td>84.52 ± 18.80</td>
<td>83.37 ± 18.20</td>
<td>0.685</td>
</tr>
<tr>
<td>Inferior-superior difference</td>
<td>5.89 ± 17.10</td>
<td>$-2.89 \pm 19.86$</td>
<td>0.002</td>
</tr>
</tbody>
</table>

Comparison was done using Student $t$-test.
RNFL, retinal nerve fiber layer.
Data are means ± SD, unless indicated otherwise.

**FIGURE 3.** Scatterplots show the relationship between the disc–foveal angle and RNFL thickness measured using Cirrus-OCT. The inferior-superior difference was defined as the inferior quadrant RNFL thickness minus the superior quadrant RNFL thickness in an individual. Pearson’s correlation coefficient $R$ values are shown.
To measure the position of the fovea relative to the optic disc, we used the disc–foveal angle determined by fundus photography, which is the standard method for quantifying cyclotropia in strabismus clinics.\(^{10,26}\) The effect of static ocular counter-roll, a compensatory torsional eye movement during head tilt, is reported to remain within \(1^\circ\), provided the head tilt was \(<5^\circ.\)\(^ {26}\) The disc–foveal angle is not affected by laterality, sex, or age.\(^ {11}\) However, small amounts of changes in physiological ocular rotation exist among each test session, which may affect the intertest measurement reproducibility of peripapillary RNFL thicknesses.\(^ {27}\) Therefore, in this study, we compensated for the potential effect of the ocular rotation on the disc–foveal angle by using fundus photographs overlaid on spectral-domain (SD)-OCT images (Fig. 1).\(^ {19}\) Similar to results in previous studies,\(^ {8,11,20}\) the mean disc–foveal angle of our study participants was \(6.08^\circ \pm 3.48^\circ.\) As shown in Figure 2, there was considerable variation in the normal disc–foveal angle, and most values were positive, which indicates that the fovea is positioned below the optic disc.

The development and progression patterns in the superior and inferior retina differ in glaucomatous damage.\(^ {28–30}\) The neuroretinal rim in normal eyes is broadest on the inferior side.\(^ {31,32}\) In addition, the RNFL thickness on the inferior side tends to be slightly thicker than on the superior side in normal subjects.\(^ {3–35}\) However, the superior VF corresponding to the inferior retina is involved more frequently in the early stages of glaucoma, with faster progression than the inferior VF.\(^ {34,35}\) In addition, the inferotemporal meridian was found to be the most frequent location where RNFL progression was detected.\(^ {36}\)

The regional susceptibility of the inferior temporal optic disc to glaucomatous damage appears to be associated with the inferior foveal position relative to the optic disc. Hood et al.\(^ {47}\) suggested that, because of the characteristic foveal position, the inferior temporal side of the optic disc is more crowded, with a higher density of retinal ganglion cell axons than other disc regions, rendering the region more vulnerable to glaucomatous damage. In this study, as the fovea became more parallel with the optic disc, the superior RNFL increased significantly \((P = 0.003)\), whereas the inferior RNFL and I-S differences decreased \((P = 0.010 \text{ and } P < 0.001, \text{ respectively})\) (Fig. 3). In addition, eyes with a more inferior foveal position relative to the optic disc (greater disc–foveal angle) had a thicker inferior RNFL and a greater I-S difference than eyes with the fovea positioned parallel to the optic disc (lesser disc–foveal angle) (Table 1). Our results support the hypothesis that the relative foveal position is one of the key factors determining the RNFL distribution.

Previous studies have found that myopia redistributes the RNFL with axial elongation.\(^ {37}\) With increased AL, there is temporalization of the retinal vessels and thickening of the temporal RNFL.\(^ {14,25}\) In agreement with this finding, we observed thickening of the average RNFL and on the temporal side with increased AL \((P = 0.001 \text{ and } P < 0.001, \text{ respectively})\) (Fig. 4). Consistent with the previous studies where the Littmann formula was used to eliminate the effect of ocular magnification related to the AL,\(^ {25,38}\) we found that the average RNFL thickness increased with AL. The thicker average RNFL thickness in myopic eyes compared to nonmyopic eyes may be related to the overshooting effect related to the adjustment for ocular magnification. In addition, eyes with a larger retinal surface area (i.e., eyes with long AL) may retain more RNFL.

### Table 2. Linear Regression Analysis of Disc–Foveal Angle and Clock-Hour-Based Retinal Nerve Fiber Layer Thickness

<table>
<thead>
<tr>
<th>Clock Hour</th>
<th>(R)</th>
<th>(R^2)</th>
<th>(P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>–0.075</td>
<td>0.006</td>
<td>0.322</td>
</tr>
<tr>
<td>12</td>
<td>–0.308</td>
<td>0.095</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>1</td>
<td>–0.074</td>
<td>0.005</td>
<td>0.352</td>
</tr>
<tr>
<td>2</td>
<td>0.065</td>
<td>0.004</td>
<td>0.396</td>
</tr>
<tr>
<td>3</td>
<td>0.032</td>
<td>0.001</td>
<td>0.671</td>
</tr>
<tr>
<td>4</td>
<td>0.109</td>
<td>0.012</td>
<td>0.155</td>
</tr>
<tr>
<td>5</td>
<td>0.258</td>
<td>0.056</td>
<td>0.002</td>
</tr>
<tr>
<td>6</td>
<td>0.198</td>
<td>0.039</td>
<td>0.008</td>
</tr>
<tr>
<td>7</td>
<td>–0.017</td>
<td>0.000</td>
<td>0.825</td>
</tr>
<tr>
<td>8</td>
<td>–0.182</td>
<td>0.033</td>
<td>0.016</td>
</tr>
<tr>
<td>9</td>
<td>–0.094</td>
<td>0.009</td>
<td>0.215</td>
</tr>
<tr>
<td>10</td>
<td>–0.102</td>
<td>0.010</td>
<td>0.180</td>
</tr>
</tbody>
</table>

**Figure 4.** Scatterplots show the relationship between the axial length and RNFL thickness measured using Cirrus-OCT. The inferior-superior difference was defined as the inferior quadrant RNFL thickness minus the superior quadrant RNFL thickness in an individual. Pearson’s correlation coefficient \(R\) values are shown.
than normal eyes, considering that optic disc size is positively correlated with AL39 and that the larger optic disc is associated with more retinal nerve fiber axons, as shown in the previous histomorphometric study.40

Intriguingly, we also observed that the position of the fovea becomes parallel to the optic disc as the distance between the fovea and disc center increases \( (P = 0.033) \), which may suggest that there is asymmetrical enlargement in the posterior sclera between the superior and inferior regions in general axial myopia. The posterior sclera is more immature, produces more collagen, and is more extensible than the anterior and equatorial scleral regions, which makes it particularly susceptible to myopic changes.41 The posterior sclera is the outer shell of the posterior pole and changes in the posterior sclera are reflected in the posterior pole, as shown in studies that analyzed outer deformities of the posterior sclera in cross-sectional images of the macula and optic disc.15,16 Further studies using other imaging devices, such as swept-source OCT and magnetic resonance imaging (MRI) are needed to elucidate the changes in the posterior sclera with axial elongation in general myopia.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Superior Quadrant</th>
<th>Inferior Quadrant</th>
<th>Temporal Quadrant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.083 (0.203)</td>
<td>-0.238 (0.157)</td>
<td>-0.154 (0.177)</td>
</tr>
<tr>
<td>Disc area</td>
<td>1.091 (3.700)</td>
<td>7.593 (2.857)</td>
<td>8.684 (3.228)</td>
</tr>
<tr>
<td>Axial length</td>
<td>-2.622 (1.231)</td>
<td>0.187 (0.950)</td>
<td>-2.435 (1.073)</td>
</tr>
<tr>
<td>Disc-foveal angle</td>
<td>1.886 (0.396)</td>
<td>-0.882 (0.305)</td>
<td>1.004 (0.345)</td>
</tr>
</tbody>
</table>

*I-S difference was designated as the difference between the inferior and superior retinal nerve fiber layer (RNFL) thicknesses.

One of the limitations of this study was that it was clinically based and not population-based screening. The participants were all Koreans of similar age. In this study, participants with concurrent ophthalmic abnormalities or with a best-corrected VA of \(< 20/20\) were excluded. Furthermore, by virtue of our study design, the information regarding the shifts of disc–foveal angle with progressive vision loss cannot be addressed. Future studies of ocular rotational orientation in imaging eyes with vision loss or progressive vision loss are necessary. In addition, most participants were myopic, and we adjusted the measurement of RNFL thickness by using the Littmann formula21 to remove the potential bias of AL-related ocular magnification. However, a population-based study including individuals with various refractive errors, as well as different ethnicities and ages, is needed to confirm our findings.

In summary, the foveal position relative to the optic disc was a significant determinant of the normal RNFL thickness profile. The relative position of the fovea was affected by the distance between the fovea and disc center. Knowledge of the normal anatomical variation associated with the relative foveal position will help to identify and follow glaucoma patients.
Disc-Foveal Angle and RNFL Thickness

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