Macular Measurements Using Spectral-Domain Optical Coherence Tomography in Chinese Myopic Children

Si Chen, Ning Dong, Xiaofang Ren, Tuohong Zhang, and Lin Xiao

Department of Ophthalmology, Beijing Shijitan Hospital, Capital University of Medical Sciences, Peking, People’s Republic of China

School of Public Health, Peking University, Peking, People’s Republic of China

PURPOSE. To evaluate the macular thickness/volume in Chinese myopic children using spectral-domain optical coherence tomography (SD-OCT) and assess its correlation with spherical equivalent refraction (SER), axial length (AL), sex, and age.

METHODS. A total of 194 eyes from 194 children (aged 6–17 years old) with emmetropia (–0.5 diopters [D] < SER ≤ 0.5 D), low myopia (–3.0 D < SER ≤ –0.5 D), and moderate to high myopia (SER ≤ –3.0 D) were recruited in the study. Each child underwent standardized ophthalmic examinations including visual acuity (VA), cycloplegic refraction, and AL measurement. The macular thickness for the nine Early Treatment Diabetic Retinopathy Study (ETDRS) regions and the average macular thickness/volume were measured and calculated.

RESULTS. Analyses of macular thickness for the ETDRS regions showed that the fovea was the thinnest of the nine regions, followed by the inner ring; the inner ring was the thickest. When compared to children with emmetropia or low myopia, children with moderate to high myopia tended to have greater foveal thickness, thinner quadrant-specific thickness in the outer ring, and smaller average macular thickness/volume. Also, there were significant differences in foveal, superior outer, inferior outer, and temporal outer quadrants among lowest, middle, and highest AL groups. Boys were found to have greater macular thickness than girls in fovea and inner ring regions.

CONCLUSIONS. Our study highlights the variations and sex differences of macular thickness/volume in Chinese myopic children using SD-OCT.

Keywords: myopia, optical coherence tomography, refractive error

Myopia is a common ocular condition in children, and epidemiologic studies show a progressive increase in the prevalence of the condition, particularly in East Asia in such areas as Singapore, the Chinese mainland, and Hong Kong. The highest reported prevalence of myopia in children is in urban China, with figures ranging from 5.7% in 5 year olds, 30.1% in 10 year olds, and 78.4% in 15 year olds. Myopia is a potentially blinding ocularopathy, which is shown to be associated with glaucoma, cataract, and retinal detachment, as well as neovascular macular degeneration. The clinical consequences and corresponding economic burden caused by myopia and myopic complications makes it a major and urgent concern. Therefore, the assessment of macular parameters such as macular thickness and macular volume in myopic children is of significance when evaluating ocular conditions that are likely to induce macular thickening or thinning.

A number of studies have reported the correlation between macular thickness and refractive error or axial length (AL) using a noninvasive method, optical coherence tomography (OCT). However, the conclusions were partly inconsistent in terms of regional and racial variations. In addition, most of those studies used the time-domain OCT (TD-OCT) modality, which is limited as it fails to include the outer segment (OS) of the photoreceptor inner and outer segment junction (IS/OS) and retinal pigment epithelium (RPE) layers owing to an insufficient axial resolution. Recently, a new method, spectral-domain OCT (SD-OCT), surpassed the TD-OCT in technology. The advantages of SD-OCT include highly increased image acquisition, approximately twice the axial resolution, relatively reduced motion artifact, and significantly increased signal-to-noise ratio as compared with TD-OCT. Accordingly, several studies on macular thickness and volume using SD-OCT have been reported recently among children, young adults, or a wide range of age with one or mixed ethnicity. However, investigation of macular thickness and its relationship with refractive error or AL in Chinese myopic children using SD-OCT have yet to be reported.

Therefore, the purpose of this study is to perform a tentative exploration of macular thickness and volume in Chinese myopic children using SD-OCT (Cirrus HD-OCT; Carl Zeiss Meditec, Dublin, CA, USA) and offer a clue for the macular characteristic in this population.

MATERIALS AND METHODS

Study Participants

Participants aged from 6 to 17 years were recruited from the ophthalmology clinic of Beijing Shijitan Hospital from October 2012 to October 2013. This study was approved by the Ethics Committee of Beijing Shijitan Hospital, Capital Medical University, Beijing, People’s Republic of China. All procedures
adhered to the tenets of the Declaration of Helsinki. Informed consents about the nature of this investigation were explained to the children and legal guardians, and written consents were obtained from one legal guardian before the examination was carried out.

The inclusion criteria were as follows: age between 6 and 17 years, Chinese ethnicity, best corrected visual acuity (BCVA) \( \geq 0.8 \), intraocular pressure (IOP) < 21 mm Hg, normal optic nerve head without an increased cup-disc ratio (\( \geq 0.5 \)) or a narrowed neuroretinal rim, no glaucoma family history, no ocular surgery or trauma history, no ocular diseases except for refractive error, and no systemic diseases, including hypertension and diabetes.\(^2\) Also, those who could not cooperate on any of the examination procedures were excluded from our study, and only data from the right eye were used for further statistical analysis. Participants in this research were classified by spherical equivalent refraction (SER) as emmetropia (\(-0.5 \, \text{diopter} \, [\text{D}] < \text{SER} \leq 0.5 \, \text{D}\)), low myopia (\(-3.0 \, \text{D} < \text{SER} \leq -0.5\, \text{D}\)), moderate to high myopia (\(\text{SER} < -3.0 \, \text{D}\)).\(^3\)\(^4\)

Moreover, participants were separated into three groups according to the tertile levels of AL.\(^6\)\(^2\)\(^4\)

**Eye Examinations**

All participants underwent a comprehensive ophthalmologic examination, including assessment of uncorrected visual acuity and BCVA, slit-lamp biomicroscopy, direct funduscopy, and IOP measurement. Additionally, AL was measured using IOL Master (Carl Zeiss, Jena, Germany), and the average of five measurements was recorded when the values differed by less than 0.1 mm and presented no poor signal.\(^18\) or the measurements were repeated. Pupillary dilation was induced by atropine for 3 days, three times per day for participants 12 years old or younger, and by four drops of 1\% cyclopentolate 5 minutes apart for those older than 12 years. Cycloplegic refraction was assessed by auto-refractometry (Auto Ref-Keratometer RK-F1; Canon, Tokyo, Japan) after pupillary dilation, and the average refractive error values of three repeated measurements were recorded. The SER values were calculated for analysis (SER = spherical error \( \pm 50\% \) of cylindrical error).

Finally, a macular thickness scan was performed by the same experienced technician (CS) in those included subjects, using Cirrus HD-OCT with the macular cube 512 \( \times 128 \) protocol through the dilated pupil. The right eye was examined first and then the left for each subject. After the participant was properly seated with the examined eye focusing on an internal fixation target and the fovea centered on the scanning laser image, the data were captured within a 6 \( \times 6\) mm\(^2\) region. The region was parted automatically corresponding to the Early Treatment Diabetic Retinopathy Study (ETDRS).\(^2\)\(^2\) Specifically, the thickness of macula was segmented into three concentric circles with diameter of 1 mm, 3 mm, and 6 mm, the thicknesses of which were termed as fovea, inner ring, and outer ring, respectively. Meanwhile, the inner and outer rings were equally divided into four quadrants: superior, nasal, inferior, and temporal. In all, for each eye, thicknesses of nine quadrants and average thickness/volume of the 6 \( \times 6\) mm\(^2\) macular cube were calculated and presented by the instrument. In addition, the operator was required to ensure that the scans were completely centered, without eye movement or blinking, before saving the images. Only signal strengths of \( \geq 8 \) were included in the analysis.\(^19\)\(^2\)\(^2\)

**Statistical Analysis**

Univariate analysis of variance (ANOVA) was applied to compare macular thickness across the quadrants. One-way ANOVA was used to identify the difference of each macular parameter among groups with emmetropia, low myopia, and moderate to high myopia, and among groups with AL in the lowest, middle, and highest tertiles. A Bonferroni post hoc test was applied for multiple comparisons when any significant difference was recognized in ANOVA. Pearson correlation analysis and partial correlation analysis were used to identify the correlations between macular parameters and SER, AL, age, and sex for all included subjects. Mean \( \pm 1 \) SD was calculated in the analysis. A \( P < 0.05 \) was considered to be statistically significant. All statistical analyses were performed using SPSS for Windows (Version 16.0; Microsoft Corp., Redmond, WA, USA).

RESULTS

A total of 205 children participated in this study, of which 11 were excluded for the following reasons: poor cooperation for OCT scanning for three boys (two 6 year olds and an 8 year old) and two girls (both aged 7 years), low signal strength in two girls (aged 12 and 15 years) and three boys (two 7 year olds and a 12 year old), and poor scan centration in a 7-year-old boy who had refused to undergo a repeated scan. Finally, 194 children (108 boys, 86 girls) with a mean age of 10.15 \( \pm 2.61 \) (6–17 years old) were available for further analysis. The mean SER and AL of the 194 eyes from 194 children were \(-2.25 \pm 2.47\) D (\(-11 \) to 0.5 D) and 24.26 \( \pm 1.39\) mm (21.48–27.93 mm), respectively. The mean signal strength of included images was 9.19 \( \pm 0.77\) (8–10).

Analyses of macular thickness for the nine ETDRS regions among all the 194 patients are presented in Figure 1, and the values among different refractive status are presented in Figure 2. Topographically, of the nine regions, the fovea was the thinnest, followed by the outer ring, and the inner ring was the thickest. Quadrant-specific discrepancies were larger in the outer ring compared to the inner ring (\( P < 0.001 \)). In the inner ring, macular thicknesses in nasal and superior quadrants were the thickest, followed by the inferior quadrant, and macular thickness in temporal quadrant was the thinnest (Univariate ANOVA; \( P < 0.001 \)). In the outer ring, the nasal macular thickness was the thickest, followed by the superior, inferior, and temporal quadrants (univariate ANOVA; \( P < 0.001 \)).
Comparisons of macular parameters among the three groups stratified by tertile of AL in each ETDRS subfield are presented in Table 2 and Supplementary Figure S2. There were significant differences in foveal, superior outer, inferior outer, and temporal outer quadrants among the AL groups (one-way ANOVA; \(P = 0.011, 0.030, 0.002, \) and 0.004, respectively). Among the three groups, statistically significant differences were also indentified in the average macular thickness and average macular volume (one-way ANOVA; \(P = 0.004\) and 0.006, respectively). No significant difference was detected in the quadrants of the inner ring. Further Bonferroni post hoc tests showed that subjects with highest AL had thicker foveal thickness, thinner macular thickness in outer ring (except for the nasal quadrant), and smaller average macular thickness and average macular volume than subjects with emmetropia.

Comparisons of macular parameters among the three groups stratified by sex in each ETDRS subfield are presented in Table 3 and Supplementary Figure S3. Boys had significantly thicker macular thickness than girls in the foveal, superior inner, nasal inner, inferior inner, temporal inner, and temporal outer quadrants (independent-sample \(t\)-test; \(P < 0.01, 0.01, 0.04, <0.01, <0.01, \) and 0.01, respectively). There were no significant differences in average macular thickness and average macular volume between boys and girls.

Correlation analyses between macular parameters and other variables are shown in Table 4. Macular thickness in the foveal, nasal outer, inferior outer, and temporal outer quadrants were significantly correlated with SER (Pearson correlation analysis; \(P = 0.003, 0.055, 0.026, 0.003, \) respectively). Also, the average macular thickness and average macular volume were significantly correlated with SER (Pearson correlation analysis; \(P = 0.003, 0.014, \) respectively). However, after adjustment for AL, age, and sex, only the macular thickness in nasal outer quadrant remained significantly correlated with SER (partial correlation analysis; \(P = 0.004\)). Macular thickness in foveal, inferior outer, and temporal outer quadrants were significantly correlated with AL (Pearson correlation analysis; \(P = 0.001, 0.004, 0.003, \) respectively). Also, the average macular thickness and average macular volume were significantly correlated with AL (Pearson correlation analysis; \(P = 0.001, 0.008, \) respectively). However, after adjustment for SER, age, and sex, no correlations between macular thickness/volume and AL remained significant. Significant correlations between macular thickness and age were detected in foveal and superior inner and nasal inner quadrants (Pearson correlation analysis; \(P = 0.007, 0.050, 0.011,\) after adjustment for SER, AL, and sex, the correlations in the superior inner and nasal inner quadrants remained significant (partial correlation analysis; \(P = 0.059, 0.031, \) respectively). There were significant correlations between macular thickness and sex in fovea, all four quadrants of the inner ring and the temporal outer quadrant (Pearson correlation analysis; \(P = <0.001, 0.011, 0.039, 0.001, <0.001, <0.001, \) and 0.010, respectively), and significant correlations were indentified after adjustment for SER, AL, and age, with the exception of the nasal inner quadrant (partial correlation analysis; \(P = 0.001, 0.012, 0.002, 0.001, \) and 0.003, respectively).

**Discussion**

In this study, macular measurements were performed to investigate the characteristics of macular thickness and volume in Chinese myopic children using SD-OCT.
Table 1. Comparison of Macular Parameters Measured Using Cirrus HD-OCT Among Emmetropia, Low Myopia, and Moderate to High Myopia

<table>
<thead>
<tr>
<th></th>
<th>Group S1</th>
<th>Group S2</th>
<th>Group S3</th>
<th>P Value†</th>
<th>Post Hoc†</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Macular thickness, μm</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Fovea</td>
<td>235.22 ± 19.39</td>
<td>240.93 ± 17.35</td>
<td>244.13 ± 22.26</td>
<td>0.045</td>
<td>S3 &gt; S1</td>
</tr>
<tr>
<td>Superior inner ring</td>
<td>319.40 ± 17.95</td>
<td>317.72 ± 14.87</td>
<td>315.50 ± 19.37</td>
<td>0.467</td>
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</tr>
<tr>
<td>Nasal inner ring</td>
<td>313.76 ± 27.81</td>
<td>319.09 ± 14.59</td>
<td>315.37 ± 21.06</td>
<td>0.332</td>
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</tr>
<tr>
<td>Inferior inner ring</td>
<td>314.36 ± 16.44</td>
<td>313.16 ± 14.72</td>
<td>307.89 ± 18.09</td>
<td>0.067</td>
<td></td>
</tr>
<tr>
<td>Temporal inner ring</td>
<td>306.38 ± 17.16</td>
<td>302.69 ± 14.29</td>
<td>301.97 ± 18.52</td>
<td>0.296</td>
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</tr>
<tr>
<td>Superior outer ring</td>
<td>284.31 ± 14.82</td>
<td>283.51 ± 13.03</td>
<td>278.16 ± 24.85</td>
<td>0.122</td>
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</tr>
<tr>
<td>Nasal outer ring</td>
<td>302.95 ± 14.56</td>
<td>299.42 ± 14.42</td>
<td>293.40 ± 16.24</td>
<td>0.002</td>
<td>S1 &gt; S3</td>
</tr>
<tr>
<td>Inferior outer ring</td>
<td>269.50 ± 12.14</td>
<td>268.88 ± 15.64</td>
<td>260.85 ± 13.46</td>
<td>0.001</td>
<td>S1 &gt; S3; S2 &gt; S3</td>
</tr>
<tr>
<td>Temporal outer ring</td>
<td>268.31 ± 13.69</td>
<td>263.11 ± 13.00</td>
<td>258.13 ± 14.00</td>
<td>&lt;0.001</td>
<td>S1 &gt; S3</td>
</tr>
<tr>
<td>Average macular thickness, μm</td>
<td>285.64 ± 27.95</td>
<td>280.23 ± 11.99</td>
<td>274.34 ± 11.67</td>
<td>0.004</td>
<td>S1 &gt; S3</td>
</tr>
<tr>
<td>Average macular volume, mm³</td>
<td>10.00 ± 0.51</td>
<td>10.01 ± 0.45</td>
<td>9.77 ± 0.41</td>
<td>0.004</td>
<td>S1 &gt; S3; S2 &gt; S3</td>
</tr>
</tbody>
</table>

Data are mean ± SD.
* One-way ANOVA.
† Bonferroni post hoc test.

Compared with macular measurements from studies using Heidelberg SD-OCT,16,18,20 and Topcon SD-OCT,9,21 the macular thicknesses obtained in the present research using Cirrus HD-OCT were thinner than those using Heidelberg SD-OCT, but were thicker than those using Topcon SD-OCT. The discrepancy among the different SD-OCT devices is probably due to the differences in the way the instruments identify the outer boundary of the retina. The Cirrus HD-OCT measures retinal thickness between the internal limiting membrane (ILM) and the outer border of RPE. In contrast, the Topcon SD-OCT measures retinal thickness from the ILM to the anterior border of RPE, while the Heidelberg SD-OCT measures from the ILM to the RPE-Bruch’s membrane-choriocapillaris complex.8,9 Compared with published data on Cirrus HD-OCT,14,19,22 we found that the macular thicknesses in most of the ETDRS regions and average macular thickness/volume in our study were smaller than those in previous reports, especially in the foveal subfield (the difference being 12–14 μm). While we are not sure of the reasons for the difference, we speculate that race, sex, and age might play a role since two of the previous studies focused on Caucasian children14,19 and the other was on young myopic Korean males aged 19 to 25.22 The variations in macular parameters among different races, sex, and age groups need further clarification.

Our study showed that, as a whole, the fovea was the thinnest region, followed by the outer ring, while the inner ring was the thickest, which is in accordance with most of the previous reports using TD-OCT6,23–25 or SD-OCT.9,14,22 Regardless of age, sex, SER, and AL, there was no wide variation in macular thickness among the inner four quadrants, whereas there was a large diversity among the outer four quadrants, with the macular thickness in the outer nasal quadrant being much thicker than the other three quadrants. Ooto et al.9 and Zhang et al.23 deduced that the greater discrepancy of the

Table 2. Comparison of Macular Parameters Measured Using Cirrus HD-OCT Among Lowest, Middle, and Highest Tertile of Axial Length

<table>
<thead>
<tr>
<th></th>
<th>Group A1</th>
<th>Group A2</th>
<th>Group A3</th>
<th>P Value†</th>
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<td></td>
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<tr>
<td>Fovea</td>
<td>236.37 ± 17.94</td>
<td>248.25 ± 17.32</td>
<td>246.22 ± 22.81</td>
<td>0.011</td>
<td>A1 &lt; A3</td>
</tr>
<tr>
<td>Superior inner ring</td>
<td>317.60 ± 17.46</td>
<td>319.06 ± 16.95</td>
<td>315.84 ± 17.65</td>
<td>0.575</td>
<td></td>
</tr>
<tr>
<td>Nasal inner ring</td>
<td>313.85 ± 26.34</td>
<td>317.15 ± 17.39</td>
<td>317.97 ± 19.24</td>
<td>0.507</td>
<td></td>
</tr>
<tr>
<td>Inferior inner ring</td>
<td>312.20 ± 15.53</td>
<td>312.26 ± 17.02</td>
<td>311.03 ± 17.20</td>
<td>0.894</td>
<td></td>
</tr>
<tr>
<td>Temporal inner ring</td>
<td>303.69 ± 16.34</td>
<td>303.35 ± 17.47</td>
<td>303.64 ± 16.27</td>
<td>0.992</td>
<td></td>
</tr>
<tr>
<td>Superior outer ring</td>
<td>285.08 ± 14.51</td>
<td>283.78 ± 13.29</td>
<td>277.19 ± 24.20</td>
<td>0.040</td>
<td>A1 &gt; A3</td>
</tr>
<tr>
<td>Nasal outer ring</td>
<td>300.02 ± 14.79</td>
<td>299.68 ± 13.81</td>
<td>295.92 ± 17.50</td>
<td>0.251</td>
<td></td>
</tr>
<tr>
<td>Inferior outer ring</td>
<td>271.48 ± 13.05</td>
<td>265.18 ± 14.35</td>
<td>262.78 ± 14.66</td>
<td>0.002</td>
<td>A1 &gt; A2; A1 &gt; A3</td>
</tr>
<tr>
<td>Temporal outer ring</td>
<td>265.94 ± 13.14</td>
<td>264.80 ± 14.65</td>
<td>258.41 ± 13.32</td>
<td>0.004</td>
<td>A1 &gt; A3; A2 &gt; A3</td>
</tr>
<tr>
<td>Average macular thickness, μm</td>
<td>285.51 ± 26.62</td>
<td>279.72 ± 12.17</td>
<td>274.58 ± 11.60</td>
<td>0.004</td>
<td>A1 &gt; A3</td>
</tr>
<tr>
<td>Average macular volume, mm³</td>
<td>10.02 ± 0.50</td>
<td>9.99 ± 0.44</td>
<td>9.78 ± 0.41</td>
<td>0.006</td>
<td>A1 &gt; A3; A2 &gt; A3</td>
</tr>
</tbody>
</table>

Data are mean ± SD.
* One-way ANOVA.
† Bonferroni post hoc test.
macular thickness in the outer ring may be owing to the anatomic nature of the retinal nerve fiber layer (RNFL), with vertical symmetry but horizontal asymmetry. Superior and inferior arcuate bundles of nerve fibers were crowded within the inner region of the macula and were relatively dispersed within the outer ring, and the papillomacular bundle within the outer nasal region of the macula led to the nasal quadrant being much thicker than the other three quadrants of the outer ring.9,23

The comparison of macular thickness in the ETDRS regions among SER groups in our study showed that with worsening degree of myopia, there was a trend toward increasing thickness in the foveal region and thinning in both the inner and outer rings, which was in accordance with most of the previously published studies.6,22,23,25,26 In the comparison of macular thickness among the three tertiles of AL, the fovea was thickest and the outer ring the thinnest in the highest tertile.9,23

While there was significant correlation between foveal thickness and both SER and AL in the Pearson correlation analysis, there was no significant correlation in the partial correlation analysis. A number of studies have reported significant correlation between macular thickness and SER or AL.6,7,9,22,23,25 but the analyses were not controlled for other possible confounding variables. Our study showed that after...
adjustment for the other factors, the association between macular thickness and SER or AL was insignificant. Our results concur with the findings of the multivariate analyses of the multicenter Spanish study that evaluated the similar age range (from 4 to 17 years) of subjects and used the same OCT device (Cirrus HD-OCT). Neither SER nor AL was independently related to macular thickness after adjusting for other confounding factors. The results indicate that the correlation is more complicated than expected. Many factors, including refractive status, AL, age, sex, race, and other myopia-related biological factors may collectively play a role in determining the macular thickness.

The sex comparison of macular parameters in the present study showed that boys had significantly thicker macular thickness at the fovea, the four inner quadrants, and the temporal outer quadrant when compared to girls. While significant differences were noted in some quadrants between boys and girls, however, there was no significant difference in average macular thickness and volume. The possible explanation is that the quadrants that have no differences enjoy more weight than the quadrants that have some differences. Taken together, no significant difference was found in average macular thickness and volume. The sex differences were consistent with previous studies conducted both in children and in adults.9,14,20–23,30,31 It has been speculated that the intersex discrepancy may be due to differences in the anatomic configurations of the retinal layers beneath the RNFL that constitute most of the retina, and the lack of intersex differences in the outer ring might be attributed to the arcuate (superior and inferior) configuration of RNFL, as the RNFL is relatively thinner in the inner ring compared with the outer ring.3,25 Additionally, Ooto et al.3 attributed the intersex difference in the temporal outer quadrant to the smallest RNFL thickness in the temporal raphe of parapapillary region. As there is relatively insufficient quadrant-related evidence, particularly in SD-OCT reports,5,9,18,20–23,32 further investigations are needed to reveal if the layers of retina or other factors are responsible for the intersex difference.

There was no significant correlation between age and most quadrants of ETDRS regions when the data were adjusted for SER, AL, and sex in this study. It was in accordance with previous reports on Chinese children, but the results were different when compared to those obtained from Chinese adults using stratus OCT.25,52 Researchers have demonstrated histologically that the decreased number of ganglion cell axons leads to the thinner RNFL in the older age groups.53,54 Albeit may result in a decrease in macular thickness among adults, Barrio-Barrio and colleagues’ study in Caucasian children using the Cirrus HD-OCT also identified a significant correlation is that the quadrants that have no differences enjoy more weight than the quadrants that have some differences. Taken together, no significant difference was found in average macular thickness and volume. The sex differences were consistent with previous studies conducted both in children and in adults.9,14,20–23,30,31 It has been speculated that the intersex discrepancy may be due to differences in the anatomic configurations of the retinal layers beneath the RNFL that constitute most of the retina, and the lack of intersex differences in the outer ring might be attributed to the arcuate (superior and inferior) configuration of RNFL, as the RNFL is relatively thinner in the inner ring compared with the outer ring.3,25 Additionally, Ooto et al.3 attributed the intersex difference in the temporal outer quadrant to the smallest RNFL thickness in the temporal raphe of parapapillary region. As there is relatively insufficient quadrant-related evidence, particularly in SD-OCT reports,5,9,18,20–23,32 further investigations are needed to reveal if the layers of retina or other factors are responsible for the intersex difference.

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The limitations of the present study include the relatively insufficient number of high myopic children, which may have limited our exploration of their macular characteristics. Also, the results from a monocentric clinic-based study may be less representative than a multicenter and population-based one. Although the relatively large sample with an even distribution of age and sex in our study may have partly compensated for the shortage, our results need to be further confirmed. Besides, differences in SER might lead to differences in OCT image size. Although too minor to be detected, these differences might have affected our results to some degree. In addition, similar to previous study,25 we have also included only the right eye of each individual for analysis. The biases that may be induced are likely to be minor.

In conclusion, our study showed that the Chinese myopic children, especially those with moderate to high myopia, have thicker fovea, thinner macular thickness in the inner and outer rings, and smaller average macular thickness/volume in the 6 × 6-mm² area. However, after adjustment for age, sex, and AL, the correlation between macular thickness/volume and SER were nonsignificant. Furthermore, boys had a thicker central macular thickness compared to girls. Our study demonstrates the characteristics of macular thicknesses in Chinese myopic children.

Acknowledgments

The authors thank Monisha E. Nongpiur, PhD, for her helpful advice and writing support in the preparation of this manuscript.

Disclosure: S. Chen, None; B. Wang, None; N. Dong, None; X. Ren, None; T. Zhang, None; L. Xiao, None

References

12. Eriksson U, Alm A, Larsson E. Is quantitative spectral-domain superior to time-domain optical coherence tomography (OCT)


