Prevalence and Characteristics of Myopic Retinopathy in a Rural Chinese Adult Population

The Handan Eye Study

Li Qin Gao, MD; Wu Liu, MD; Yuan Bo Liang, MD, PhD; Feng Zhang, MD; Jie Jin Wang, MMed, PhD; Yi Peng, MD; Tien Yin Wong, FRCSE, PhD; Ning Li Wang, MD, PhD; Paul Mitchell, MD, PhD, FRACO; David S. Friedman, MD, PhD

Objective: To determine the prevalence, characteristics, and risk factors for myopic retinopathy in a rural population in Northern China.

Methods: The Handan Eye Study is a population-based study of eye disease in rural Chinese individuals 30 years or older. Eligible residents underwent a detailed ophthalmic examination including standardized visual acuity tests and retinal photography after pupil dilation. Myopic retinopathy was defined to include signs of staphyloma, lacquer cracks, Fuchs spot, and myopic chorioretinal atrophy.

Results: Of the 6830 participants, 6603 (96.7%) had gradable photographs in at least 1 eye for assessment of myopic retinopathy. The mean (SD) age was 51.9 (11.8) years. Myopic retinopathy was observed in 60 participants (84 eyes), a person-specific prevalence of 0.9% (95% confidence interval, 0.7%-1.1%). Twenty-four (40.0%) had bilateral disease. Higher myopic retinopathy prevalence was associated with older age (P < .001) and increasing myopic spherical equivalent refractive error (P < .001). Mean (SD) spherical equivalent refraction was −12.3 (6.1) dipters for eyes with myopic retinopathy compared with −1.6 (1.6) dipters in myopic eyes without myopic retinopathy (P < .001). Bilateral blindness or low vision as defined by best-corrected visual acuity was present in 14 participants (24.6%) with myopic retinopathy. Staphyloma was the most frequent myopic retinopathy sign (86.9%), followed by chorioretinal atrophy (56.0%), lacquer cracks (36.9%), and Fuchs spot (14.3%).

Conclusions: Myopic retinopathy was detected in 0.9% of rural Chinese individuals 30 years or older. The prevalence of myopic retinopathy was lower than that in the Beijing Eye Study but was similar to white individuals of similar age in the Australian Blue Mountains Eye Study.

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MYOPIA IS A MAJOR PUBLIC HEALTH PROBLEM IN CHINESE PERSONS. THE PREVALENCE OF HIGH MYOPIA (SPHERICAL EQUIVALENT [SE] REFRACTION < −5.0 DIOPTERS [DI]) HAS BEEN REPORTED TO BE 8.2% IN JAPANESE PERSONS, 6.9% IN SINGAPOREANS, 3.3% IN CHINESE PERSONS IN BEIJING, CHINA, AND 2.3% IN CHINESE PERSONS IN TAIWAN, HIGHER THAN THAT IN WHITE AND HISPANIC POPULATIONS, IN WHICH PREVALENCE HAS RANGED FROM 0.87% TO 2.4%.

Individuals with high myopia have an increased risk of myopic retinopathy. Myopic retinopathy involves a spectrum of pathologic abnormalities affecting the posterior pole of the sclera, choroid, and retina, including posterior staphyloma, lacquer cracks in the Bruch membrane, geographic areas of atrophy of the retinal pigment epithelium and choroid, and choroidal neovascularization, sometimes described as the Fuchs spot.

Myopic retinopathy is one of the major causes of low vision in working-aged populations. Myopic macular degeneration was found to be the most frequent cause of visual impairment in subjects aged between 35 and 75 years in the Rotterdam Study. In Asian individuals, myopic retinopathy was found to be the third leading cause of bilateral low vision and the leading cause of monocular blindness among Japanese individuals 40 years or older and the second leading cause of visual impairment among Chinese individuals 40 years or older. The Beijing Eye Study (BES) reported that myopic retinopathy was present in 3.1% of the study participants 40 years or older who resided in suburban and urban areas of Bei-
In contrast, the prevalence of myopic retinopathy was only 1.2% in a suburban sample of older Australians 50 years or older.12

In this report, we aimed to estimate the prevalence of myopic retinopathy in a rural adult Chinese population living in Northern China and report the prevalence of vision loss due to myopic retinopathy. We also aimed to describe the characteristics of and risk factors for myopic retinopathy in this rural Chinese population-based sample.

STUDY DESIGN AND POPULATION

The Handan Eye Study is a population-based cross-sectional study designed to determine the prevalence of blindness, visual impairment, and common eye diseases in a rural population in Northern China.17 The Beijing Tongren Hospital Ethics Committee approved the study protocol, and written informed consent was obtained from all participants. The study has been described in detail elsewhere.17 In brief, 7557 eligible residents of Yongnian County, Handan, Hebei Province, 30 years or older, were selected randomly using a stratified cluster sampling technique with probabilities proportionate to the size of the population in each cluster. Participants were requested to visit Yongnian County Hospital for a detailed examination. Those who declined to visit the hospital were offered a simplified evaluation at a temporary field site established in the village and those who further declined to visit the temporary site were offered a limited examination conducted at home. All fieldwork was conducted from October 2006 to October 2007.

EYE EXAMINATIONS

At the study clinic, participants underwent an extensive and standardized examination procedure that included visual acuity (VA) testing, a detailed clinical examination, and ocular imaging. Visual acuity was assessed under standardized lighting conditions using the Early Treatment Diabetic Retinopathy testing protocol with a logMAR chart, read at a distance of 4 m. For those who could not see any letters on the chart at 4 m, vision was tested at 1 m, allowing VAs as low as 1/40 (0.025) to be recorded. If no letters could be read correctly at 1 m, VA was recorded as counting fingers, hand movements, or light perception.

Subjective refraction was performed by a trained and certified study optometrist for all subjects with VA worse than 20/20 in either eye. Auto Refractor-Keratometer (KR8800; Topcon, Tokyo, Japan) readings were used as the starting point for subjective refraction, and refinement of sphere, cylinder, and axis was performed until the best VA was obtained (best-corrected VA [BCVA]). The SE refraction of each eye was calculated using the spherical power in diopters plus half the cylindrical power (in diopters). Myopia was defined using an SE refraction of less than −0.5 D and high myopia, an SE refraction of less than −3.0 D. Low vision was defined as a BCVA less than 20/60 but 20/400 or more and blindness was defined as a BCVA less than 20/400 in the better eye, following the World Health Organization criteria.10

Slitlamp examination (Topcon SL-2F; Topcon) was performed by study ophthalmologists after pupil dilation, at which time any cataract was assessed using the Lens Opacities Classification System, grading nuclear color, nuclear opalescence, cortical cataract, and posterior subcapsular cataract.20 Axial length was measured using a 10-MHz A/B mode ultrasonography device (Cine Scan; Quantel Medical, Clermont-Ferrand, France).

RETINAL PHOTOGRAPHS AND GRADING

Dilated 45° digital stereoscopic color retinal photographs of Early Treatment Diabetic Retinopathy standard field 113 (centered on the optic disc) and standard field 2 (centered on the macula, nonstereoscopic) were taken of each eye by trained and certified photographers. The Topcon TRC-NW65/75 (Topcon) camera was used at the beginning of the study, and a Canon CR-DGi with a 20D SLR back (Canon, Tokyo) was used later and for most subjects.

Fundus photographs were graded by a grader (L.Q.G.), and a retinal specialist (F.Z.) reassessed the photographs that were suspected to have myopic retinopathy signs and made a final diagnosis. Both observers were masked to the participants’ other information such as refractive error status and axial length to minimize bias. Reliability was assessed in 100 participants (200 eyes) using the κ statistic, and subjects with SE refraction worse than −5.0 D accounted for a quarter of all participants. Of these 100 participants, 15 (22 eyes) had myopic retinopathy according to the final diagnosis; 21 eyes with staphyloma, 8 eyes with lacquer cracks, 10 eyes with myopic chorioretinal atrophy, and 1 eye with the Fuchs spot. The following κ coefficients for intragrader consistency were found: 0.85 for staphyloma, 0.70 for lacquer cracks, 0.66 for Fuchs spot, 0.87 for chorioretinal atrophy, and 0.98 for an overall diagnosis of myopic retinopathy.

Myopic retinopathy was defined when any of the following signs were present: staphyloma, lacquer cracks, Fuchs spot, or myopic chorioretinal atrophy.12 Staphyloma was diagnosed when ectasia was seen with a clearly defined border. The classification of staphyloma was similar to that used by Curtin12 according to the fundus area in which the ectasia was located. Lacquer cracks were diagnosed when fine, irregular, yellowish-white lines were present, indicative of linear breaks in the Bruch membrane. Choroidal atrophy was diagnosed as present when there was a scallop-shaped pale area with well-defined hyperpigmented borders. The Fuchs spot was diagnosed as present when there was heavy pigment deposition at the fovea. The diagnosis of staphyloma, lacquer cracks, Fuchs spot, or myopic chorioretinal atrophy also required the copresence of tilted and oblique disc, beta peripapillary atrophy, or another myopic retinopathy lesion. Such additional myopia-related signs assisted in differentiating staphyloma from coloboma; lacquer cracks from angiod streaks; Fuchs spot from age-related maculopathy, idiopathic choroidal neovascularization, or toxoplasmosis; and myopic chorioretinal atrophy from the atrophic signs of age-related maculopathy, toxoplasmosis, or laser scars.

STATISTICAL ANALYSIS

Statistical analyses were performed using SAS software version 9.1.3 (SAS Institute Inc; Cary, North Carolina). Statistical analyses included the t test, χ² test, and logistic regression. Prevalence rates, odds ratios, and 95% confidence intervals (CIs) are reported. The prevalence of myopic retinopathy and visual impairment were analyzed by subject (person specific), and the characteristics of myopic retinopathy were analyzed by eye (eye specific). Analyses of associations were performed using logistic regression models for person-specific data and generalized estimating equation models for eye-specific data.

RESULTS

Of the 7557 eligible subjects, 6830 (90.4% response rate) participated in the study. Of the 6830 participants, 114 (1.7%) were examined at home and thus these subjects had no refractive error data or retinal photographs taken.
After excluding 227 subjects who had either no photographs or ungradable photographs because of dense media opacities and poor quality, 6603 participants (96.7%) had gradable photographs for the assessment of myopic retinopathy in at least 1 eye. The mean (SD) age of these participants was 51.9 (11.8) years and 3067 (46.4%) were male.

**PREVALENCE OF MYOPIC RETINOPATHY**

Myopic retinopathy was diagnosed in 84 eyes of 60 patients, giving a person-specific prevalence of 0.9% (95% CI, 0.7%-1.1%). The prevalence of myopic retinopathy was 1.2% (95% CI, 0.9%-1.6%) among persons 50 years or older and 0.4% (95% CI, 0.2%-0.6%) in those younger than 50 years. Figure 1 shows the age- and sex-specific prevalence of myopic retinopathy. Among participants 70 years or older, though women had a higher prevalence (4.6%) than men (1.6%), it was just short of statistical significance ($P=.051$). Participants with myopic retinopathy were older (mean [SD] age, 60.3 [13.0] years) than those without myopic retinopathy (mean [SD] age, 51.8 [11.7] years; $P<.001$).

Of the 6603 participants, 6409 had both refractive error data and retinal photographs taken of the more myopic eye of the 2 eyes. There were 24.5% (1572 of 6409) who had refractive levels between −0.5 and −5.0 D and 2.1% (133 of 6409) worse than −5.0 D. Figure 2 shows person-specific myopic retinopathy prevalence in the more myopic eye by SE refraction, excluding 4 eyes of 3 participants who had myopic retinopathy with a history of myopia or a family history of myopia but had missing data on refractive errors. While only 0.3% of participants with myopia less than −5.0 D had retinopathy, 11.1% of those with myopia levels from −5.0 D to −7.9 D had retinopathy, and 65.7% of those with more than −8.0 D had retinopathy ($P<.001$). The mean (SD) SE refraction of eyes with myopic retinopathy (80 of 2637) was −12.3 (6.1) D (range, −1.4 D to −26.3 D), compared with −1.6 (1.6) D (range, −0.6 D to −17.0 D) in myopic eyes without myopic retinopathy (2557 of 2637; $P<.001$).

**MYOPIC RETINOPATHY AND VISUAL ACUITY**

After adjusting for age, sex, and lens status, the mean BCVA of eyes with myopic retinopathy (Snellen equivalent 20/40) was significantly worse than the mean BCVA in eyes without myopic retinopathy (Snellen equivalent 20/25; $P<.001$). For the better-seeing eye, BCVA-defined blindness was present in 4 participants (7.0%) with myopic retinopathy and low vision was present in 10 participants (17.5%) of this group (after excluding 4 eyes of 3 participants without visual acuity data). After adjusting for age, sex, and cataract grade, eyes with myopic retinopathy were substantially more likely than eyes without these signs to be visually impaired, defined by BCVA (odds ratio, 133.6; 95% CI, 68.5-260.4).

**CHARACTERISTICS OF MYOPIC RETINOPATHY**

Among the 60 participants with myopic retinopathy in at least 1 eye, 23 (38.3%) were male and 24 (40.0%) had
myopic retinopathy bilaterally. Staphyloma was the most frequent myopic retinopathy sign noted, followed by chorioretinal atrophy, lacquer cracks, and Fuchs spot (Table 1). The lowest median BCVA (20/800) and the highest median myopia (−17.4 D) were observed in eyes with the Fuchs spot, followed by chorioretinal atrophy (median BCVA, 20/160; median SE, −15.3 D), lacquer cracks (median BCVA, 20/80; median SE, −13.6 D), and staphyloma (median BCVA, 20/80; median SE, −12.0 D). Staphyloma was present in 73 eyes of 52 subjects, and 21 cases (40.4%) were bilateral. Posterior staphyloma was further categorized by location: posterior pole, macular, peripapillary, nasal, and inferior centered. The distribution of the different locations of staphyloma is summarized in Table 2. When present bilaterally, staphyloma location was often symmetrical (85.7%).

ASSOCIATIONS WITH MYOPIC RETINOPTHY

Myopic retinopathy was significantly associated with age, a positive family history of myopia, and longer axial length in a generalized estimating equation model (Table 3).

The overall prevalence of myopic retinopathy (0.9%) in this rural Chinese population 30 years or older is similar to that reported by Hu23 in east, midsouth, and northeast areas of China (0.95%) but slightly lower than that reported from the Blue Mountains Eye Study (BMES) in a predominantly white urban population of Australian 49 years or older (1.2%).12 and a Shaanxi Chinese population (1.3%; mean age, 34.4 years; range, 1 to 91 years)24 and much lower than that observed in the BES population 40 years or older (3.1%).18 Different age compositions in these study samples may influence the prevalence findings. For example, the prevalence rate of myopic retinopathy among study participants 50 years or older in our sample (1.2%) is exactly the same as that of the BMES sample (H11350 49 years). However, our myopic retinopathy prevalence of 1.0% (95% CI, 0.8%-1.3%) among participants 40 years or older is substantially lower than the 3.1% (95% CI, 2.6%-3.6%) prevalence reported in the BES population of similar age.18 After direct age standardization of the Handan Eye Study population to the world population in 2000, the myopic retinopathy prevalence of 1.5% among participants 50 years or older is similar to the corresponding prevalence (1.2%) reported in the BMES.12

There are many other factors that could have influenced the prevalence findings, such as ethnicity, the definition of myopic retinopathy used, and differences in diagnostic methods or criteria. Duke-Elder25 defined pathological myopia as myopia accompanied by degenerative changes, particularly those at the posterior pole of myopic eyes. To further refine this definition and to allow for comparisons across studies, we adopted the definitions used by Vongphanit et al in the BMES report.12 The discrepancy of myopic retinopathy prevalence between the BES and our study may be due to the different definition of myopic chorioretinal atrophy. Chorioretinal atrophy was the late stage of the myopic degenera-

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**Table 1. Numbers and Proportion of Eyes and Participants With Posterior Pole Lesions of Myopic Retinopathy in the Handan Eye Study Population**

<table>
<thead>
<tr>
<th>Type of Posterior Pole Chorioretinal Lesions</th>
<th>Eyes (%)</th>
<th>Participants (%)</th>
<th>No. of Participants With Bilateral Involvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posterior staphyloma</td>
<td>73 (86.9)</td>
<td>52 (86.7)</td>
<td>21</td>
</tr>
<tr>
<td>Chorioretinal atrophy</td>
<td>47 (56.0)</td>
<td>35 (58.3)</td>
<td>12</td>
</tr>
<tr>
<td>Lacquer cracks</td>
<td>31 (36.9)</td>
<td>26 (43.3)</td>
<td>5</td>
</tr>
<tr>
<td>Fuchs spot</td>
<td>12 (14.3)</td>
<td>10 (16.7)</td>
<td>2</td>
</tr>
<tr>
<td>Any posterior pole lesion</td>
<td>84</td>
<td>60</td>
<td>24</td>
</tr>
</tbody>
</table>

**Table 2. Characteristics of Eyes With Staphyloma in the Handan Eye Study Population**

<table>
<thead>
<tr>
<th>Staphyloma Site</th>
<th>Posterior Pole</th>
<th>Macular</th>
<th>Peripapillary</th>
<th>Inferior</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. (%) of eyes</td>
<td>49 (67.1)</td>
<td>14 (19.2)</td>
<td>5 (6.9)</td>
<td>5 (6.9)</td>
</tr>
<tr>
<td>Age, y, mean (SD)</td>
<td>59.6 (13.4)</td>
<td>58.8 (13.2)</td>
<td>58.5 (17.6)</td>
<td>60.0 (11.3)</td>
</tr>
<tr>
<td>No. of men</td>
<td>13</td>
<td>4</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>No. of women</td>
<td>22</td>
<td>6</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>BCVA, median</td>
<td>20/100</td>
<td>20/100</td>
<td>20/40</td>
<td>20/63</td>
</tr>
<tr>
<td>SE, median (range)</td>
<td>−13.6 (−18 to −8.4)</td>
<td>−12.1 (−15.3 to −10.9)</td>
<td>−14.5 (−15.3 to −6.1)</td>
<td>−9.3 (−9.3 to −8.5)</td>
</tr>
<tr>
<td>No. of eyes with staphyloma and another coexisting lesion</td>
<td>Chorioretinal atrophy</td>
<td>29</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>Lacquer cracks</td>
<td>18</td>
<td>7</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Fuchs spot</td>
<td>10</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Abbreviations:** BCVA, best-corrected visual acuity; SE, spherical equivalent.
We found that BCVA-defined blindness or of the blindness and low-vision cases in the Handan study previously reported, myopic retinopathy accounted for 11.0% of the cases.

Prior studies have indicated that pathologic myopia is more frequent in Asian adult populations. After age standardization, the prevalence of myopia in our rural Chinese population, 50 years or older, was similar to that reported from an Australian sample of similar age range (15% in the BMES and 18.2% in ours). Our rural population therefore may not have as high a proportion of myopia or high myopia compared with other Chinese populations. Our myopia prevalence of 18.8% (95% CI, 17.7%-19.9%) and high myopia prevalence of 1.8% (95% CI, 1.5%-2.2%) among participants 40 years or older is lower than the prevalence of 22.9% (95% CI, 21.7%-24.2%) and 3.3% (95% CI, 2.8%-3.8%), respectively, reported in the Beijing Chinese population of similar age. This in combination with the different definitions described earlier may contribute to our relatively lower prevalence of myopic retinopathy. This important difference in the prevalence of myopia between Handan and Beijing may in part be due to differences in educational level, less time spent outdoors during childhood, genetic factors, or other unknown environmental factors or could be due to chance variation in the subjects selected for the population-based studies.

Myopic retinopathy has been reported to be the second leading cause of bilateral blindness and low vision in Chinese populations, defined using BCVA. As previously reported, myopic retinopathy accounted for 11.0% of the blindness and low-vision cases in the Handan study population. We found that BCVA-defined blindness or low vision was present in 14 participants (24.6%) with myopic retinopathy. This number differs slightly from our previous report based on the clinical examination rather than photographic analysis for myopic retinopathy.

Characteristics of myopic retinopathy lesions may vary across populations. Comparing these signs between our rural Chinese population and other study populations, the proportion with staphyloma was 86.7% among participants with myopic retinopathy in our sample, higher than the 52.3% reported by the BES and 59.1% in the BMES sample. Posterior centered staphyloma was the most frequent type of staphyloma (67.1%) in our Chinese population, while peripapillary staphyloma was the most frequent type in the BMES (45.7%) and BES population. The different frequencies of staphyloma location could be explained by the much higher mean (SD) myopic SE (−12.3 [6.1] D) in our myopic retinopathy cases than that in the BMES (−6.1 [5.2] D) and BES (−9.0 [4.5] D) samples.

The myopic retinopathy characteristics in our population were similar to those reported from Japan. Regardless of the different locations across different groups, staphyloma was consistently found to be the most frequent lesion type for people with myopic retinopathy in most studies, followed by chorioretinal atrophy, lacquer cracks, and Fuchs spot. The chorioretinal atrophy was reported to be the most common lesion type and was present in all eyes with myopic retinopathy in the BES, which may be due to the different definitions used by the BES to define chorioretinal atrophy.

As in previous studies, the myopic retinopathy prevalence increased with age and increasing myopic refractive error and was significantly associated with positive family history of myopia and longer axial length. Similar to the BMES sample, no significant associations were found between myopic retinopathy and glaucoma, nuclear opalescence, nuclear color, cortical cataract, or posterior subcapsular cataract. Some but not all studies have reported an association between myopic retinopathy and female sex. In our study, women with myopic retinopathy outnumbered men among those 70 years or older (Figure 1). This sex difference, however, was not statistically significant.

Potential limitations of our study should be mentioned. Two types of fundus camera were used in the study. Though both cameras provided 45° digital stereoscopic color retinal photographs and gave similar results in grading of myopic retinopathy, they had some minor difference in image quality. The prevalence of myopic retinopathy may have been underestimated if the photographic field of the posterior pole was not sufficiently wide enough to detect the staphyloma or stereopsis from the stereo photographs was inadequate. The exclusion of mild levels of retinal pigment epithelium changes from the atrophic changes in grading may also underestimate the prevalence.

In conclusion, we report the age- and sex-specific prevalence of myopic retinopathy in a population-based sample of rural Chinese individuals. The prevalence of myopic retinopathy was lower than that in the BES but was similar to white individuals of similar age in the Australian BMES.

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Table 3. Factors Associated With Myopic Retinopathy in the Handan Eye Study

<table>
<thead>
<tr>
<th>Factors</th>
<th>OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, per 10 y</td>
<td>2.2 (1.3-3.8)</td>
</tr>
<tr>
<td>Female</td>
<td>2.1 (0.9-5.0)</td>
</tr>
<tr>
<td>Illiterate</td>
<td>0.5 (0.2-1.3)</td>
</tr>
<tr>
<td>Family history of myopia</td>
<td>4.5 (1.8-11.7)</td>
</tr>
<tr>
<td>Lens</td>
<td></td>
</tr>
<tr>
<td>Nuclear opalescence</td>
<td>0.3 (0.03-2.5)</td>
</tr>
<tr>
<td>Nuclear color</td>
<td>4.4 (0.8-22.5)</td>
</tr>
<tr>
<td>Cortical cataract</td>
<td>2.0 (0.8-4.9)</td>
</tr>
<tr>
<td>Poster subcapsular cataract</td>
<td>0.3 (0.07-1.0)</td>
</tr>
<tr>
<td>Axial length, per 1 mm</td>
<td>3.8 (2.7-5.3)</td>
</tr>
<tr>
<td>Glaucoma</td>
<td>1.3 (0.2-10.5)</td>
</tr>
</tbody>
</table>

Abbreviations: CI, confidence interval; OR, odds ratio.

a Estimates from a multivariable-adjusted generalized estimating equation model.
Author Affiliations: Beijing Tongren Eye Center, Beijing Tongren Hospital, Capital Medical University, Beijing Ophthalmology and Visual Science Key Lab, Beijing (Drs Gao, Liu, Liang, Zhang, Peng, and N. Wang), and Handan Eye Hospital, Hebei Province (Dr Liang), China; Centre for Eye Research Australia, Department of Ophthalmology, University of Melbourne, Melbourne (Drs J. Wang and Wong), and Centre for Vision Research, Department of Ophthalmology, Western Clinical School, University of Sydney, Sydney (Dr J. Wang); Singapore Eye Research Institute, Yong Loo Lin School of Medicine, National University of Singapore (Dr Wong); and Wilmer Eye Institute, Johns Hopkins University (Drs Mitchell and Friedman), and Department of International Health, Johns Hopkins, Bloomberg School of Public Health (Dr Friedman), Baltimore, Maryland.

Correspondence: Ning Li Wang, MD, PhD, Beijing Tongren Eye Center, Beijing Tongren Hospital, Capital Medical University, Beijing Ophthalmology and Visual Science Key Lab, No. 1, Dong Jiao Min Xiang, Dongcheng District, Beijing 100730, China (wningli@vip.163.com).

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