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PREVALENCE AND CHARACTERISTICS OF MYOPIC DEGENERATION IN AN ADULT CHINESE AMERICAN POPULATION: THE CHINESE AMERICAN EYE STUDY

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Abstract

Purpose—To characterize and provide population-based prevalence estimates of myopic degeneration (MD) among Chinese Americans, the fastest growing minority population in the United States in the last decade.

Design—Population-based, cross-sectional study.

Methods—1523 Chinese American adults with myopia, aged 50 years and older, residing in the City of Monterey Park, California, underwent an interview and comprehensive eye exam, including subjective and objective refraction, and stereoscopic fundus photography. For each participant, the eye with the worse myopic refractive error was included in this analysis. MD was assessed in a masked manner by an expert grader.

Results—The prevalence of any MD was 44.9% among myopes based on the presence of any degenerative lesion secondary to myopia. The prevalence was 32.2% when MD was defined by a modified version of the Meta-Analysis for Pathologic Myopia. The prevalence of specific lesions included: tessellation (31.7%), tilted disc (28.1%), peripapillary atrophy (7.0%), staphyloma (5.7%), diffuse atrophy (6.4%), lacquer cracks (2.6%), intrachoroidal cavitation (2.2%), patchy

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atrophy (0.9%), and end-stage MD (0.2%). The prevalence of MD was higher among older myopes, and among participants with more severe myopia and longer axial length ($p < .001$).

Conclusions—These data provide the first population-based estimates of MD in Chinese Americans and indicate that a high proportion of Chinese Americans might be at risk for MD and associated visual complications. Prevalence of MD in this cohort of Chinese Americans was higher than that observed in other East Asian populations, and in people of other ethnicities.

INTRODUCTION

A spectrum of degenerative structural changes can develop in the posterior region of the globe, secondary to myopia. These myopic degenerations (MD) include pathologic abnormalities in the chorioretinal tissue, sclera, and optic nerve that can lead to irreversible visual impairment (VI) in advanced stages.^{1–3} Despite MD's potentially deleterious impact on visual function and quality of life, this remains an understudied topic.^{4,5} Hospital-based and histologic studies have described MD's clinical significance and morphologic changes, but only a few population-based investigations have adequately characterized the prevalence of MD and its impact on VI or blindness.^{6,7} In ocular epidemiologic studies, prevalence estimates have varied due to differences in definitions of MD, race, and study site.^{6,8–13} Some estimates have also lacked precision, due to calculations based on small numbers of subjects with myopia or high myopia.^{2,7,9–11} While a clear understanding of this public health issue is relevant to all racial and ethnic groups, the high prevalence of myopia in Chinese Americans makes this population an ideal group for characterizing the frequency and clinical significance of MD.¹⁴

East Asians, including Chinese and Chinese Americans, have a higher prevalence of myopia and resulting complications, compared to other racial/ethnic groups.^{10,11,14,15} The results from studies on the Chinese diaspora, conducted in Asia, may not be generalizable to Chinese Americans, who have different experiences with respect to environment, education, lifestyle, and access to care and utilization.¹⁶

The prevalence of myopia in the North America is expected to grow to 58% by 2050, and a high number of myopes are expected to have MD as the proportion of older adults in the population grows.^{12,17,18} Chinese Americans constitute the fastest growing minority population in the US in the last decade.^{19,20} Due to the high prevalence of myopia and aging of the population,¹⁴ Chinese Americans are expected to experience a disproportionate burden of myopia-related complications.^{7,12,19} Consequently, pathologic changes secondary to myopia will become major causes of VI and blindness in adults of Chinese descent.^{12,13,15,21} MD is of particular concern, because it is often bilateral and irreversible.^{6,22}

To advance our understanding of this growing public health challenge, we utilized data from the Chinese American Eye Study (CHES), a large, population-based ophthalmologic study designed to characterize the prevalence of the major causes of VI and blindness in Chinese Americans.¹⁶ CHES data provided the opportunity to obtain a robust estimate of MD prevalence among this unique segment of the US population, using the most recent classification recommendations from an international consortium of experts: a modified

version of the Meta-Analysis for Pathologic Myopia (META-PM) classification and grading system.⁷

In this report, we present age- and sex-specific population-based prevalence estimates of MD, overall and by specific component lesion. Further, we characterize the prevalence of MD and its lesions by myopia severity and axial length. We also compare our estimated prevalence from CHES with those from other studies on the Chinese population, and other racial and ethnic groups. Associated risk factors will be examined and reported separately.

METHODS

Study Cohort

CHES is a population-based study of eye disease in self-identified Chinese Americans 50 years and older, residing in the City of Monterey Park, California, from 2010 to 2013. The study area was chosen based on the communities' dense and stable population of Chinese Americans. Details of the study design and baseline data have been reported.¹⁶ In brief, a door-to-door census, performed by trained study interviewers, identified eligible participants in all dwelling units within 10 census tracts. A screening interview confirmed eligibility, including age and self-identified Chinese ancestry. Eligible residents were informed about the study and invited to participate in both a clinical interview and a comprehensive eye examination at the local eye examination center (LEEC).

After obtaining written informed consent, all eligible participants were interviewed to assess detailed sociodemographic status and medical history and a comprehensive eye examination. Refractive error was assessed during the eye examination. If presenting visual acuity (VA) was 20/20 or better (≥ 55 letters) in each eye according to the Early Treatment Diabetic Degeneration Study protocol (ETDRS), refraction was the presenting spectacle correction or plano. Otherwise, a noncycloplegic autorefractor (Humphrey Autorefractor) was performed. For participants with VA less than 20/20, refraction was refined by subjective refraction using standard protocols. Status of visual impairment (VI) was assessed. VI was defined as the best corrected VA of 20/40 or less in the affected eye.

Stereoscopic fundus photographs of both eyes were obtained and stored in a digital imaging database (Digital Healthcare, EyeQ version 5.6) that allowed measurement of linear length, angles, and areas. Photographs of all of the participants' eyes were reviewed for focus, clarity, and field definition. Based on those assessments, a grade was assigned for overall quality to indicate whether further evaluation was possible. The grading of the fundus photo involved a preliminary and detailed grading followed by an edit and adjudication, if necessary. The preliminary grade assessed image quality, any retinal pathology, and general disease status of both the target disease and common retinal conditions of interest. The detailed grade expanded upon the preliminary grade and evaluated the component lesions of particular target disease(s).

This analysis included participants with a gradable fundus photograph and refractive error data available for at least one phakic eye without evidence of refractive surgery. Participants

with aphakia or pseudophakia in both eyes were excluded, as their myopia status could not be assessed.

For each participant, the eye with the worse myopic refractive error was included in this analysis. For evaluation of MD in CHES, a modification of the myopic degeneration classification scheme developed by the META-PM international consortium was used.⁷ The objective was to evaluate retinal images for optic disc changes related to pathologic myopia, as well as macular changes due to MD, such as tessellated fundus, various types of atrophy, posterior staphyloma, and exudative lesions secondary to pathologic myopia. An expert grader (SM) at the Wisconsin Ocular Epidemiology Grading Center, with more than 30 years of experience retinal grading, and a panel member of the META-PM consortium, assessed each eye in a masked manner for the presence of lesions associated with MD.

This study was reviewed and approved by the institutional review board (IRB) and the ethics committee of the University of Southern California, and all study procedures adhered to the principles outlined in the Declaration of Helsinki for research involving human subjects.

Definitions of Outcome Variables

1. **MD Lesions:** Changes to the optic nerve—including disc tilt, disc index, and peripapillary atrophy—were assessed. Staphyloma, bulging, or excavation of the sclera, usually secondary to increasing axial length of the globe, was also assessed. The rest of the chorioretinal changes were assessed in the macular area. These included: disc tilt, abnormal disc index, peripapillary atrophy (PPA), tessellation, lacquer cracks, diffuse atrophy, patchy atrophy, intra-choroidal cavitation (ICC), and end-stage MD. End-stage MD was defined by the presence of any end-stage exudative lesion associated with pathologic myopia, including intraretinal hemorrhage, subRPE or subretinal hemorrhage, subretinal fibrous scar, choroidal neovascularization, serous retinal detachment, Fuch's spot, and atrophic macula. Care was taken to differentiate the etiology of these lesions from those associated with diabetic retinopathy, age-related macular degeneration, or other macular diseases.
2. **MD:** We operationally defined the overall outcome of MD in 2 ways. For the first definition, we considered the presence of any of MD lesions, including the maculopathies and optic nerve lesions described above. This definition included the presence of tessellation, tilted disc, PPA, diffuse chorioretinal atrophy, staphyloma, lacquer cracks, ICC, patchy atrophy, and end-stage MD. For the second definition, we followed the international photographic classification and grading system⁷ to operationally define MD. According to this system, MD was defined by the presence of any of the following macular lesions: tessellation, diffuse and patchy chorioretinal atrophy, atrophic macula, lacquer cracks, choroidal neovascularization, and Fuch's spots.⁷

Statistical Analysis

Prevalence was calculated as the ratio of the number of individuals with the condition to the total number of myopic participants with gradable fundus photographs for MD evaluation.

Prevalence estimates and 95% confidence intervals (CI) were presented for any MD and for individual MD lesions.

Age- and gender-specific prevalence estimates with 95% CIs were calculated. To further characterize the prevalence, frequency distributions for MD and different degenerative lesions were stratified by myopia severity level and axial length. Myopia was stratified into 3 categories: mild ($-0.5, > -2$ D), moderate ($-2, > -5$), and severe (worse than -5 D). Axial length was stratified into quartiles to assess prevalence in each severity level.

Sex-specific differences in prevalence were assessed by Pearson chi-square test or Fisher's exact test, as appropriate. To evaluate differences in prevalence by age (in decades), by severity of myopia, and by axial length, R*C or Freeman-Halton Chi-square tests was used, as appropriate. Cochran-Armitage trend test assessed the statistical significance of trends in prevalence by increasing age, severity of myopia, and axial length. Multivariable logistic regression was used to test for sex differences in prevalence, after adjusting for age, severity of myopia, and axial length. Age was included as a continuous variable for this particular analysis.

To compare prevalence across selected population-based studies, prevalence was calculated for CHES participants by using comparable definitions. To account for inter-study differences in age, we calculated age-standardized prevalence for each study by direct age-standardization, using the Asian population from the 2010 US Census as the standard.

All tests were conducted at a significance level of .05, and the reported p-values were 2-sided. All statistical analyses were conducted using SAS 9.4 (SAS Institute Inc., Cary, NC).

RESULTS

Study Participants

A total of 4582 participants completed the clinical examination in CHES, representing 79% of eligible participants. Overall, this cohort of Chinese Americans comprised mostly first-generation immigrants (98%), the majority of whom were born in mainland China (69%). Compared to Chinese living in California or in the US, CHES participants were slightly younger (50–59 years: 47% in CHES vs. 41% in California and 44% in the US¹⁹) and more likely to be female (63% in CHES vs. 52% in California and the US), but less likely to have 12 or more years of education (67% in CHES vs. 77% in California and the US). In CHES, 4144 (90.4%) participants had gradable fundus photograph and refractive error data. A total of 1523 participants with a spherical equivalent of -0.5 diopters or worse in either eye were evaluated for MD (Supplemental Fig 1). The participant included in this analysis were younger, more educated, more acculturated, and earned more compared to the whole cohort.

Prevalence of MD

Of the 1523 participants with myopia, 684 persons showed signs of any MD by definition 1 that includes all macular and optic nerve lesions [prevalence 44.9%, 95% CI: 42.4%–47.4%] (Table 1). These 684 participants constitute about 16.5% of all CHES participants, including myopes and non-myopes [95% CI: 15.4%–17.7%]. Table 1 also provides the prevalence of

myopic maculopathies (definition 2), including maculopathy lesions, secondary to myopia.⁷ By this definition, 490 myopes showed signs of any MD [prevalence 32.2%, 95% CI: 29.9%–34.6%].

MD was more prevalent among older people. This age-related difference was statistically significant, regardless of the definition used (Table 1). The age trend was stronger when all lesions were included in the definition (50–59 years: 39.3%, 60–69 years: 50.2%, 70–79 years: 50.4%, 80+ years: 82.6%, $p < .001$).

There were no sex-specific differences in MD prevalence (Table 1), regardless of the definition used. However, in the highest quartile of axial length (25.6 mm or more), the prevalence was 85.9% females and 73.7% for males ($p < .05$). Multivariable analysis revealed a higher prevalence in females, which remained statistically significant after controlling for age, severity of myopia, and axial length.

Prevalence of MD Lesions

The prevalence of different MD lesions is summarized in Table 2. Tessellation was the most common lesion with 31.7% prevalence. In descending order, the other lesions had the following prevalence: 28.1% for tilted disc, 16.1% for abnormal disc index, 7.0% for PPA, 6.4% for diffuse chorioretinal atrophy, 5.7% for staphyloma, 2.6% for lacquer cracks, 2.2% for ICC, 0.9% for patchy atrophy, and 0.2% for end-stage MD.

We also examined the prevalence of each lesion stratified by severity of myopia (Table 3). The results indicated a positive association between prevalence of MD lesions and severity of myopia for tessellation, tilted disc, PPA, diffuse chorioretinal atrophy, staphyloma, lacquer cracks, ICC, and patchy atrophy ($p < .001$). The exception was end-stage MD: despite the greater number of cases in the high myopia category, there was a lack of statistical significance ($p = .05$).

We also examined prevalence by axial length (Table 4). These results were suggestive of higher prevalence of MD lesions in participants with longer axial length, and were statistically significant for all MD lesions, except for end-stage MD ($p = .05$ for end-stage MD, $p < .001$ for all others).

We observed high correlation among the prevalence of different lesions (data not shown). People with more severe lesions, such as lacquer cracks, patchy atrophy and end-stage atrophy, had a high prevalence of co-existing lesions, such as tessellation, titled disc, and diffuse atrophy. There was a high prevalence of co-existing tessellation in participants with diffuse atrophy (94.9%), staphyloma (94.3%), and ICC (93.9%). All cases of lacquer cracks, patchy atrophy, and end-stage MD had tessellation. All 3 cases of end-stage MD had tilted disc, PPA, diffuse atrophy, and abnormal disc index.

VI in Macular Degeneration

We examined the status of VI in people with any MD and different MD lesions. The prevalence of VI was lowest in participants with tilted disc (12.4%). In increasing order, the prevalence of VI was as follows: 18.3% for abnormal disc index, 19.7% for tessellation,

27.3% for ICC, 38.7% for PPA, 42.3% for diffuse atrophy, and 47.1% for staphyloma. More than half of the participants with lacquer crack (66.7%) and patchy atrophy (71.7%) had VI in the affected eye (data not shown). All participants with end-stage MD had VI in the affected eye.

Among the 169 MD cases with VI, more than half had tessellation; roughly a quarter had PPA, diffuse atrophy, or staphyloma; and only 1.7% had end-stage MD (data not shown). For all of these lesions, the main cause of VI was MD and/or cataract.

Comparison with Other Studies

Differences in definitions, grading protocols, and populations make valid comparison of MD prevalence across studies difficult.^{2,7–9,11} Therefore, we reanalyzed the CHES data, adjusting the definitions and restricting the age groups to correspond with other population-based studies. We also calculated age-standardized prevalence for each of the other studies by direct method, using the Asian population from the 2010 US Census as the standard.¹⁹ Table 5 presents the results of these comparisons.

Using the same definition and age-adjustment, we found that the prevalence of MD was higher in CHES [2.9%, 95% CI: 2.4%–3.5%] than in the Handan Eye Study¹¹ [1.0%, 95% CI: 0.7%–1.4%]. Age-adjusted prevalence of MD could not be calculated for the Shihpai eye study.¹⁰ However, using the same definition and restricting to the same age-group, the prevalence in CHES was slightly higher than in the Shihpai Eye Study.¹⁰

Compared to Japanese participants in the Hisayama Eye Study,⁸ age-adjusted MD prevalence was higher in CHES [1.7% for Hisayama vs. 2.5% for CHES]. Age-adjusted MD prevalence in CHES was more than twice that of whites in the Blue Mountains Eye Study (BMES)⁶ [CHES: 2.5% (95% CI: 2.2%–3.2%); BMES: 1.0% (95% CI: 0.7%–1.4%)].

DISCUSSION

To our knowledge, CHES is the largest and most comprehensive population-based study of eye disease in a Chinese population 50 years and older; and the first ocular epidemiology study^{16,20} that provides population-based, robust estimates of age- and sex- specific prevalence of MD in a large well-defined cohort of Chinese Americans.

The overall prevalence of MD among myopes was 44.9%, based on a definition that includes all of the characteristic structural changes in the macula and optic nerve, secondary to myopia. The prevalence was 32.2% using a modified version of the META-PM definition. Among myopes, the prevalence of MD was higher in each successively older age group, and this trend was statistically significant ($p < .05$), regardless of the definition used. Previous studies have demonstrated the impact of aging on structural and functional changes in patients with myopia^{22,23} It is also possible that MD is associated with myopia duration, for which age is a surrogate.

The prevalence of MD did not vary by gender in this cohort, regardless of the definition of used. Some studies suggest a higher prevalence of MD in females.²³ In CHES, females had a higher prevalence only within the upper quartile of axial length. This difference remained

after controlling for age, severity of myopia, and axial length. Robust longitudinal data would likely provide better insight into the association of MD with age and gender.

The results from CHES indicated a higher prevalence of MD with high myopia and longer axial length. Similar statistically significant differences in prevalence of all types of MD lesions were observed by axial length and severity of myopia, with the exception of end-stage MD. Other studies have reported similar findings.^{10,22,23} Since we had only 3 cases of end-stage MD, it is likely that the small sample size explains the lack of statistical significance. In CHES, approximately 20% of people with tessellation were visually impaired. Almost two-thirds of the people with more severe MD lesions, such as lacquer cracks and patchy chorioretinal atrophy, were visually impaired. All 3 participants with end-stage MD had VI.

In the absence of a uniform grading protocol based on standard clinical definitions, comparison of prevalence across different studies is neither meaningful nor easily interpretable. To our knowledge, only 5 population-based studies from Australia, China, Japan, and Singapore have provided information on the prevalence of MD. The crude prevalence of MD in those population-based studies ranged from 0.9% to 3.3%.^{2,6,8,9,11} The estimated age-adjusted prevalence of MD was higher in CHES than in the Handan eye study.¹¹ Prevalence in CHES was also slightly higher than in the Shihpai Eye Study for people older than 65 years.¹⁰ Compared to Handan and Shihpai, CHES has a higher proportion of participants who obtained higher education, a factor that is strongly associated with the near visual tasks that contribute to the development of myopia and may lead to subsequent structural damage to the eye.²⁴ In CHES, 98% of the participants are first generation immigrants from different parts of China and hence, their early life environmental exposure is difficult to assess. However, about 78% of the participants have a history of living in the US for more than 10 years. Whether or not this late yet long-term exposure to a Westernized urban environment renders CHES participants more susceptible to MD begs further exploration.

We also compared the prevalence estimates for MD in CHES with the few available population-based studies on non-Chinese ethnicities. The participants in CHES had a higher prevalence than Japanese people from Hisayama Eye Study,⁸ and more than twice the prevalence reported for white Australians from BMES.⁶ Previous studies have suggested that people of Chinese ancestry are disproportionately impacted by MD.^{8,10,15} So it is likely that, similar to other Chinese populations, CHES participants were genetically more susceptible to MD compared to other racial and ethnic groups. Myopia and myopic degeneration is considered a complex trait that is likely influenced by both genes and environment.²⁵ Thorough analyses of genetic and environmental risk factors, as well as the interaction between these factors, based on prospective studies, are needed to shed more light on the high prevalence of MD among Chinese Americans.

CHES data suggested high correlation among the prevalence of different lesions. For example, more than 90% of participants with diffuse atrophy, staphyloma, ICC, and end-stage MD had tessellation. In addition to tessellation, all 3 cases of end-stage MD had tilted disc, PPA, diffuse atrophy, and an abnormal disc index. Longitudinal studies can confirm

these associations and provide insight into which lesions are likely to progress to vision-threatening advanced lesions, based on the frequency of lesions at baseline.

CHES has important strengths, including a large, representative sample of Chinese Americans living in California, with a high participation rate (79%) and standardized protocols for ocular examination and fundus photo grading. The large sample size (1523 myopes) allowed for precise, stable estimates of MD prevalence, both overall and specifically for each lesion. We also looked at a comprehensive panel of chorioretinal and optic nerve lesions, secondary to myopia. A limitation of the current analysis is the cross-sectional design, which limited our ability to evaluate the clinical significance of MD lesions and to characterize the patterns of progression and the sequence of changes in MD status due to aging or increasing duration of myopia. Also, by excluding participants with bilateral aphakia or pseudophakia from our analysis, we could have underestimated the effect of aging on MD.

Here, we have provided the first population-based estimates of prevalence for MD among Chinese Americans. The higher prevalence among Chinese Americans, compared to other races and ethnicities, and even other groups of the Chinese diaspora, might arise from unique interactions between genetic and environmental factors that enhance susceptibility to MD in this population. These data add to our knowledge of this growing public health challenge, and also suggest a compelling need for further prospective, longitudinal studies to characterize the incidence and progression of MD, and associated predictors, in this unique and growing population.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Overall, Age-specific, and Sex-specific Prevalence of Myopic Degeneration (MD) Among Myopes in CHES

Definition 1 ^b				Definition 2 ^c			
	Myopes	MD	% <i>a</i>	(95% CI)	MD	% <i>a</i>	(95% CI)
Total	1523	684	44.9	(42.4, 47.4)	490	32.2	(29.9, 34.6)
Age Group (Years)				Age-specific	Age-specific		
50–59	809	318	39.3	(35.9, 42.6)	210	26.0	(22.9, 29.0)
60–69	550	276	50.2	(46.0, 54.4)	201	36.6	(32.5, 40.6)
70–79	141	71	50.4	(42.1, 58.6)	64	45.4	(37.2, 53.6)
80+	23	19	82.6	(67.1, 98.1)	15	65.2	(45.8, 84.7)
<i>d_{p-value}</i>	< .001				.01		
				Sex-specific	Sex-specific		
Males	569	259	45.5	(41.4, 49.7)	190	29.9	(26.2, 33.8)
Females	954	425	44.5	(41.3, 47.7)	300	32.3	(29.3, 35.4)
<i>d_{p-value}</i>	.71				.46		

^aProportion calculated among myopes in that age group. 95% CI = 95% confidence interval^bDefinition 1 includes all degenerative lesions, including tessellation, tilted disc, peripapillary atrophy (PPA), diffuse chorioretinal atrophy, staphyloma, lacquer cracks, intra-choroidal cavitation (ICC), patchy atrophy, and end-stage myopic degeneration in eye with worse myopia.^cDefinition 2 is based on the International Photographic Classification and Grading System for Myopic Maculopathy and includes presence of tessellation, diffuse chorioretinal atrophy, lacquer cracks, patchy atrophy, macular degeneration, and neovascular maculopathy in the eye with myopia.^d*p-value from Cochran-Armitage trend test for age and Pearson chi-square for sex*

Table 2

Prevalence of Myopic Degenerative (MD) Lesions Among Myopes in CHES

Myopia Lesion				
	N	n	% ^a	95% CI
Any Lesion	1523	684	44.9	(42.4, 47.4)
Specific Lesion^b				
Tessellation	1519	482	31.7	(29.4, 34.1)
Tilted Disc	1521	427	28.1	(25.8, 30.3)
Disc Index	1523	245	16.1	(14.3, 18.0)
Peripapillary Atrophy	1523	106	7.0	(5.7, 8.2)
Diffuse Atrophy	1517	97	6.4	(5.2, 7.6)
Staphyloma	1518	87	5.7	(4.6, 6.9)
Lacquer Cracks	1517	39	2.6	(1.8, 3.4)
Intra-choroidal Cavitation	1520	33	2.2	(1.4, 2.9)
Patchy Atrophy	1517	14	0.9	(0.4, 1.4)
End-stage Myopic Degeneration	1517	3	0.2	(0.0, 0.4)

^aPrevalence among people with myopia, defined by refractive error of -0.5 D or worse; 95% CI = 95% confidence interval^bNumbers by specific lesion are not mutually exclusive; sample sizes differ due to missing values in grading for a particular lesion; maximum # with myopia in the worse eye = 1523; maximum # with any lesion = 684.

Table 3

Percent of Myopes with Myopic Degenerative Lesions Stratified by Severity of Myopia in CHES (N = 1523*)

	Mild Myopia (-0.5, > -2),	Moderate Myopia (-2, > -5),	High Myopia (-5),	<i>p for trend^d</i>
	N= 601	N= 554	N= 368	
	n (%) ^a	n (%) ^b	n (%) ^c	
Any Lesion	130 (21.7)	272(49.1)	367 (76.4)	< .001
Specific Lesion				
Tessellation	91 (15.2)	174 (31.6)	217(58.9)	< .001
Tilted Disc	59 (9.9)	176 (31.9)	191 (52.0)	< .001
Disk Index < 0.75	72 (11.9)	126 (21.4)	149 (38.7)	< .001
Peripapillary Atrophy	8 (1.3)	20 (3.6)	77 (21.0)	< .001
Diffuse Atrophy	10 (1.7)	23 (4.2)	63 (17.2)	< .001
Staphyloma	6 (1.0)	8 (1.5)	73 (19.9)	< .001
Lacquer Cracks	1 (0.2)	3 (0.6)	35 (9.5)	< .001
Intra-choroidal Cavitation	3 (0.5)	8 (1.5)	22 (6.0)	< .001
Patchy Atrophy	0	0	14 (3.8)	< .001
End-stage Myopic Degeneration	1 (0.2)	0	2 (0.5)	.28

^aPercent of mild myopics with specific lesion^bPercent of moderate myopics with specific lesion^cPercent of high myopics with specific lesion^d *p-trend*: p-value from Cochran-Armitage trend test. Numbers by specific lesion are not mutually exclusive.

Table 4
Percent of Myopes with Myopic Degenerative Lesions Stratified by Quartiles of Axial Length in CHES (N= 1509)

	Axial Length (< 23.85), N= 381 n (%) ^a	Axial Length (23.85, <24.65), N= 370 n (%) ^b	Axial Length (24.65, < 25.60), N= 381 n (%) ^c	Axial Length (25.60) N= 377 n (%) ^d	<i>p for trend</i> ^e
Any Lesion	66 (17.3)	118 (31.9)	191 (50.1)	303 (80.4)	< .001
Specific Lesion					
Tessellation	37 (9.7)	65 (17.7)	131 (34.5)	244 (64.7)	< .001
Tilted Disc	34 (9.0)	75 (20.3)	125 (32.8)	190 (50.5)	< .001
Disc Index < 0.75	10 (2.6)	34 (9.1)	66 (17.3)	132 (35.0)	< .001
Peripapillary Atrophy	1 (0.3)	7 (1.9)	10 (2.6)	86 (22.8)	< .001
Diffuse Atrophy	5 (1.3)	7 (1.9)	16 (4.2)	68 (18.1)	< .001
Staphyloma	1 (0.3)	6 (1.6)	7 (1.8)	70 (18.6)	< .001
Lacquer Cracks	0	0	3 (0.8)	35 (9.3)	< .001
Intra-choroidal Cavitation	1 (0.3)	3 (0.8)	6 (1.6)	22 (5.8)	< .001
Patchy Atrophy	0	0	0	14 (3.7)	< .001
End-stage Myopic Degeneration	0	0	1 (0.3)	2 (0.5)	.05

^aPercent in the first quartile of axial length with specific lesion

^bPercent in the second quartile of axial length with specific lesion

^cPercent in the third quartile of axial length with specific lesion

^dPercent in the fourth quartile of axial length with specific lesion

^e*p-trend*: p-value from Cochran-Armitage trend test

Table 5
Comparison of Prevalence of Myopic Degeneration in Different Population-based Studies

<i>Studies on Chinese</i>					
<i>Prevalence</i>					
Study	Ethnicity	Sample size	Age	Definition	Crude (%) Age-adjusted ^a % (95% CI)
Handan Eye Study	Rural Northern Chinese	4049	50	• Staphyloma • Chorioretinal Atrophy	1.2 1.0 (0.7, 1.4)
CHES	Urban Chinese Americans	4144	50	• Fuch's Spot • Lacquer Cracks	3.2 2.9 (2.4, 3.5)
Shihpai Eye Study ^b	Urban Chinese in Taiwan	1361	65	• Chorioretinal Atrophy • Fuch's Spot	3.0
CHES	Urban Chinese Americans	1038	65	• Lacquer Cracks	3.3
<i>Studies of non-Chinese</i>					
The Hisayama Study	Southern Japanese	1892	50	• Diffuse Chorioretinal Atrophy • Patchy Atrophy	1.7 1.8 (1.2, 2.4)
CHES	Urban Chinese Americans	4144	50	• Lacquer Cracks • Macular Atrophy	2.5 3.0 (2.5, 3.6)
Blue Mountains Eye Study	Older White Australians	3654	49	• Staphyloma • Chorioretinal Atrophy	1.2 1.0 (0.7, 1.4)
CHES	Urban Chinese Americans	4144	50	• Fuch's Spot • Lacquer Cracks	2.5 2.0 (2.2, 3.2)

^a Age-adjusted to the Chinese American population from the 2010 US census

^b Age-adjusted rate could not be calculated due to inadequate information on age-specific prevalence from Shihpai.