Clinical profile and distribution of peripheral retinal changes in myopic population in a hospital-based study in North India

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Purpose: To evaluate the prevalence of different types of peripheral retinal changes in a myopic population in North India and correlate them with axial length. **Methods:** This cross-sectional, hospital-based survey included 600 eyes of 300 myopic individuals, aged between 10 and 40 years, attending the outdoor ophthalmology clinic of a tertiary eye care hospital in North India were examined from July 2019 to July 2020. They were divided into mild, moderate, high, and severe myopia according to the spherical equivalent of refraction. Axial length was recorded. Peripheral retinal changes were examined by scleral indentation binocular indirect ophthalmoscopy. Standardized findings considered with their fundus location were lattice degeneration, white without pressure and white with pressure, snail-track degenerations, peripheral chorioretinal atrophy, retinal holes, tears, and detachment. The study was approved by the institutional ethics committee, and all participants provided informed consent. **Results:** Peripheral retinal degenerations were found in almost half (53%) of all myopes included in the study. The most common peripheral retinal degeneration found was lattice degeneration, followed by white without pressure, white with pressure, and chorioretinal atrophy. Most of the peripheral retinal degenerations were seen in the temporal quadrant of the fundus, either superotemporal or inferotemporal. There was a significant positive association between the prevalence of peripheral retinal degeneration with age, increased axial length, and severity of myopia. **Conclusion:** The results of our study indicate the necessity for careful peripheral fundus examinations of all myopes, irrespective of age and degree of myopia, for early diagnosis and better management of visual-threatening complications like retinal detachment.

Key words: Axial Length, India, myopia, peripheral fundus examination, peripheral retinal changes

Myopia has become a potential vision-threatening problem worldwide, showing a steep increase in its prevalence in the last few decades. In a meta-analysis conducted on Asian population in 2015, prevalence of myopia was found to be 24.2% in children younger than 20 years and about 30% in adults older than 40 years.[1] Globally, the prevalence of myopia has increased from 22.9% in 2000 to 28.3% in 2010, and it is estimated to reach 49.8% by 2050.[2]

Individuals with myopia have increased risks of myopic retinopathy and peripheral retinal degenerations because of continuous axial growth causing overstretching of outer coats and various degenerative changes in retina, choroid, and vitreous. It can cause peripheral retinal degenerations like lattice degeneration (LD), paving stone degeneration, white with pressure (WWP) and white without pressure (WWOP), pigmentary degenerations, and retinal tears, which can ultimately lead to vision-threatening complications like retinal detachment.[3]

Peripheral retinal degenerations are a heterogeneous group of anatomical variations, degenerative changes, and pathologic processes that can be observed ophthalmoscopically in the anterior neural retina and ora serrata region. They can be divided into intraretinal degenerations: microcystoid

degeneration, degenerative retinoschisis, pars plana cysts; retino-vitreal degenerations: LD, snail-track degeneration, WWP, and WWOP; and chorioretinal degenerations: paving stone degeneration.[4] Based on their risk to cause vision-threatening complications, they are divided into innocuous lesions (not predisposing to retinal detachment): microcystoid degeneration, paving stone degeneration, pars plana cyst and lesions predisposing to retinal detachment: LD, snail-track degeneration, WWP, and WWOP.

Several studies have demonstrated increased prevalence of peripheral retinal degenerations in association with high myopia and increased axial length (AL).[5] Myopes account for 42% of all phakic retinal detachments, and therefore, myopia is considered a risk factor for retinal breaks that lead to retinal detachment.[4]

Despite the above-mentioned potential deleterious impact on vision and quality of life, this topic remains understudied as very few population-based studies have adequately characterized the prevalence of these lesions in Indian myopic

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population. Most of the studies investigated pathologic myopia in older adults, but not in children and young adults who, when identified at an early age, can provide broader insight into management options and burden control. The present cross-sectional study is an endeavor to evaluate the prevalence of different types of peripheral retinal changes in myopic population of different age groups and sex and its correlation with AL.

Methods

This was a cross-sectional, hospital-based clinical study conducted in the ophthalmology department of a tertiary eye care hospital in North India from July 2019 to July 2020. The study was approved by the institutional ethics committee, and procedures were in accordance with the tenets of the Declaration of Helsinki. Written informed consent was obtained from all the patients or their guardians for participation in the study.

Study Population

Six hundred eyes of 300 myopic individuals of age between 10 and 40 years were included in the study. Individuals with history of any previous ocular disorders, ocular trauma, or surgery including refractive surgeries were excluded. Patients with any hereditary systemic disorders like Stickler syndrome, Down's syndrome, Marfan's syndrome, and so on, which are associated with high myopia, were excluded. Individuals with history of prolonged intake of systemic drugs like steroids or sulfonamides or those having diabetes mellitus which can cause acquired myopia due to changes in the refractive index of lens were also excluded. All eligible participants were divided into three age groups: 10–20 years, 21–30 years, and 31–40 years. To avoid the effect of any age-related changes on the refractive error like emmetropization or cataract, only patients above 10 years and below 40 years of age were included in the study.

Clinical Assessment

Best-corrected visual acuity measurement by Snellen's chart, non-cycloplegic autorefraction, and subjective cycloplegic refraction was conducted. Cycloplegia was induced with 1% cyclopentolate eye drop, one drop every 15 min for three times (Havener's recommended dose), and retinoscopy was performed 60 min later. Spherical equivalent refraction (SER) was calculated as the sum of the spherical power and half of the cylindrical power. Myopia was divided into four categories, that is, mild, moderate, high, and severe, where mild myopia was defined as spherical equivalent (SE) of <−0.50 D to −3.00 D, moderate myopia as <−3.00 D to −5.00 D, high myopia as <−5.00 D to −10.00 D, and severe myopia as <−10.00 D and above[2,6] [Fig. 1].

Ocular biometry was done using Nidek optical biometer for AL measurements, and the mean of three AL measurements was taken as the final AL. All subjects underwent a detailed slit-lamp examination for the assessment of anterior segment. After pupil dilation, central fundus examination was done using 90 D lens. Peripheral retinal changes were examined by scleral indentation binocular indirect ophthalmoscopy (BIO) by two trained ophthalmologists, and dilated fundus photographs were taken with Zeiss Visucam lite fundus camera. Standardized findings considered were LD, WWOP and WWP, snail-track degenerations, peripheral chorioretinal atrophic changes,
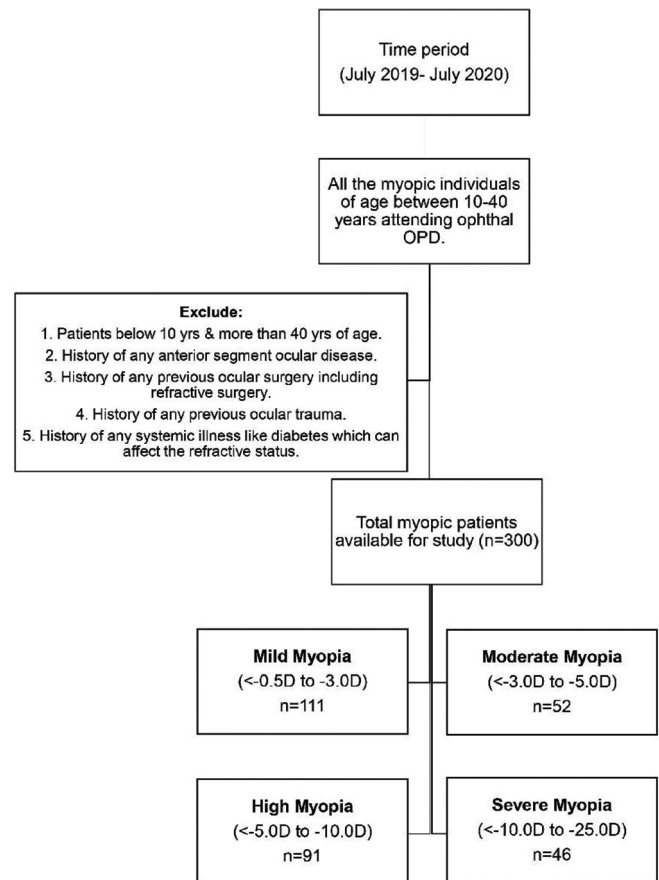
Figure 1: Flowchart of patient data pool at various levels of inclusion and exclusion stages

retinal holes/tears, and detachment [Fig. 2]. The criteria for these findings were those classically described and illustrated in published reports. All changes were subcategorized by location (superotemporal, inferotemporal, superonasal, inferonasal). Findings of both the eyes were included.

Statistical Analysis

The following formula was used for calculating the adequate sample size for prevalence study[7]: $n = (Z)^2 \, P \, (1 - P) \, / \, d^2$, where n is the sample size, Z is the statistic corresponding to level of confidence, P is expected prevalence (obtained from similar studies conducted previously), and d is precision (corresponding to effect size). Aiming for 95% level of confidence, 5% level of precision, and 63.8% expected prevalence (Elnahry *et al.*[8]), we got an estimated sample size of 83 individuals.

Chi-squared test was used to explore the association between age group, grade of myopia, gender, and occurrence of peripheral retinal degeneration. *P* value of <0.05 was considered significant. The data was analyzed by using Statistical Package for Social Sciences (SPSS) software version 21.0.

Results

Six hundred eyes of 300 myopic individuals were studied with respect to their age, sex, refractive error, grade of myopia, AL, and presence of any type of peripheral retinal degeneration. The mean (SD) age of participants was 21.21 (10.69) years. Majority

Figure 2: Fundus pictures of a few peripheral retinal degenerations seen in patients enrolled in our study: (a) lattice with snail-track degeneration and an atrophic hole at the edge; (b) white without pressure; (c) pigmented lattice with atrophic holes (sclerosed vessels forming a characteristic white network can be seen); and (d) lasered retinal hole

of the participants were in the age group 10–20 years (56.0%), followed by 21–30 years (22.7%) and 31–40 years (21.3%). Also, 55.3% of the participants were males and 44.7% were females. The mean (SD) SE of refraction (D) was -5.44 (4.21). The SE (D) ranged from -20 to -0.5. Mild myopia was present in 37.0% of the study population, followed by high myopia (30.3%), moderate myopia (17.3%), and severe myopia (15.3%). The mean (SD) of AL (mm) was 25.40 (1.97). The AL ranged from 22 to 34.37 mm.
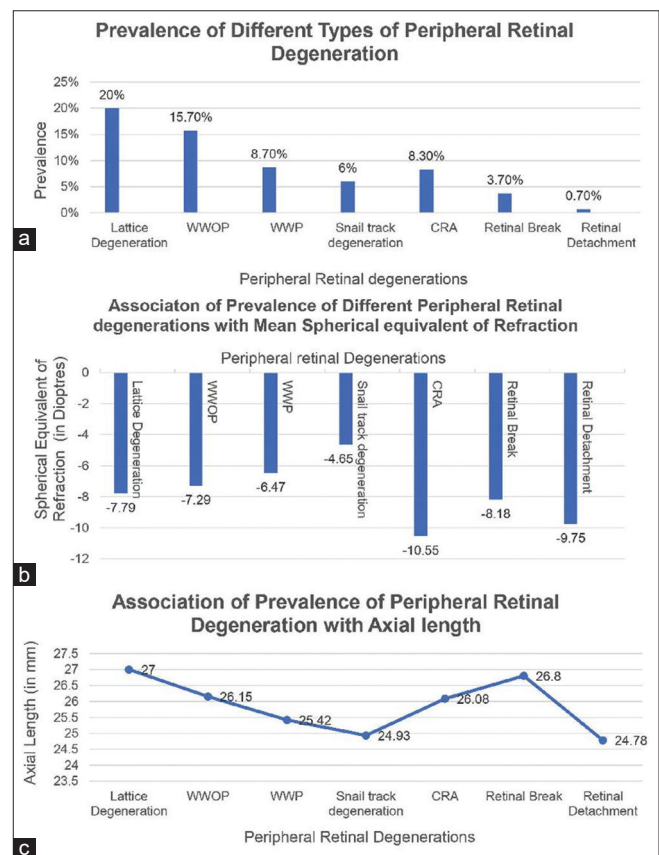
Peripheral retinal degenerations were found in almost half (53%) of all myopes included in the study. LD was present in 60 (20.0%) participants, WWOP in 47 (15.7%), followed by WWP in 26 (8.7%) participants. Eighteen (6.0%) of the participants had snail-track degeneration, 25 (8.3%) had Chorioretinal atrophic changes (CRA), 11 (3.7%) had retinal break, and two (0.7%) of the participants had retinal detachment.

LD was the commonest peripheral retinal degeneration with the mean age of presentation being 27.98 years, mostly seen in inferotemporal location; this was followed by WWOP, WWP, and CRA [Table 1a; Fig. 3a]. Most of the peripheral retinal degenerations were seen in the temporal quadrant of the fundus, either superotemporal or inferotemporal.

There was a significant positive association between the prevalence of peripheral retinal degeneration with age, increased AL, and severity of myopia. The prevalence of LD, WWOP, and CRA was significantly associated with higher AL [Table 1b; Fig. 3b, c].

Discussion

The literature on peripheral retinal changes in myopes of all grades and severity in young adults is scarce. In our study, we tried to include myopes of all grades (mild, moderate, high,

Figure 3: (a) Prevalence of different types of peripheral retinal degenerations. (b) Distribution of peripheral retinal degenerations according to the spherical equivalent of refraction. (c) Association of prevalence of peripheral retinal degenerations with axial length

Table 1a: Summary of prevalence of different peripheral retinal degenerations in myopic individuals with their most common fundus location and mean age of presentation

Type of peripheral retinal degeneration	Overall prevalence (%)	Chi-squared test P	Most common fundus location (%)	Mean age (SD)
Lattice degeneration	20	<0.001	Inferotemporal (15.3%)	27.98 (10.51)
WWOP	15.7	0.324	Superotemporal (8.3%)	19.38 (11.09)
WWP	8.7	0.100	Inferotemporal (4.7%)	18.5 (8.75)
Snail-track degeneration	6	0.040	Supero- and inferotemporal (3.7%)	16.22 (5.85)
CRA	8.3	0.009	Superotemporal (4%)	27.92 (11.84)
Retinal break	3.7	0.766	Inferotemporal (2.7%)	24.27 (11.25)
Retinal detachment	0.7	0.687	Superotemporal (0.7%)	21.00 (1.41)

WWOP=white without pressure, WWP=white with pressure

Table 1b: Association of prevalence of different peripheral retinal degenerations with mean SER and axial length

Type of peripheral retinal degeneration	Mean SER (SD)	P	Mean axial length in mm (SD)	P
Lattice degeneration	–7.79 (3.89)	<0.001	27.00 (2.17)	<0.001
WWOP	–7.29 (3.83)	<0.001	26.15 (2.13)	0.001
WWP	–6.47 (2.93)	0.034	25.42 (1.52)	0.677
Snail-track degeneration	–4.65 (2.63)	0.766	24.93 (1.36)	0.595
CRA	–10.55 (4.82)	<0.001	26.08 (1.78)	0.004
Retinal break	–8.18 (3.33)	0.008	26.80 (2.49)	0.055
Retinal detachment	–9.75 (7.42)	0.238	24.78 (0.90)	0.624

SER=spherical equivalent refraction, WWOP=white without pressure, WWP=white with pressure

Table 2: Comparison of our results with other studies

Study	Type of study	Study population	Prevalence of any type of peripheral retinal degeneration (in %)	Most common peripheral retinal degeneration and its prevalence (in %)
Elnahry *et al.*[8]	Cross-sectional	127 eyes of 77 Egyptian patients with pathologic myopia	63.8	WWOP- 37.8 LD- 11.8
Dhakal *et al.*[6]	Retrospective	29,592 Indian myopic patients aged 10-40 years	4.3	LD- 2.65 WWOP- 1.17
Chen *et al.*[9]	Cross-sectional	887 Highly myopic adult Asian males (SER <-6 D) aged 19-25 years	67	WWOP- 57.2 LD- 17
Akbani Mohd *et al.*[10]	Cross-sectional	87 Indian myopic patients of age 11-71 years	42	LD- 34.4 WWOP- 12.8
Bansal and Hubbard[11]	Retrospective case review	54 eyes of 30 highly myopic children of age ≤10 years	33	LD- 20 WWOP- 11
Lai *et al.*[12]	Cross-sectional	337 highly myopic Chinese subjects	56.1	Pigmentary degeneration- 37.7 WWOP- 21.1 LD- 13.6
Lam *et al.*[13]	Cross-sectional	213 eyes of 213 highly myopic Chinese individuals of 18-73 years of age	58	Pigmentary degeneration- 51 LD- 12
Present study, 2019	Cross-sectional	600 eyes of 300 Indian myopic individuals of age 10-40 years	53	LD- 20 WWOP- 15.7

LD=lattice degeneration, SER=spherical equivalent refraction, WWOP=white without pressure

and severe), with a wide age distribution ranging from 10 to 40 years. We included both males and females and considered both eyes of the participants.

The definitions of myopia and high myopia vary across various prevalence studies. For practical purposes, we standardized all data using an SE of ≤–0.50 D for myopia because it was the most used definition in previously published prevalence studies; it is beyond refraction measurement error and it detects myopic children at the start of their progression. We chose an SE of ≤–5.00 D for high myopia because it was commonly used; it helps to identify people at higher risk of pathologic myopia, and if uncorrected, causes vision impairment at least equivalent to the World Health Organization (WHO)-defined blindness.

Most of the studies done previously had considered prevalence of peripheral retinal degenerations only in high or pathologic myopia and had included a narrow age group of older adults, and not children and young adults.

Almost half (53%; $n = 159$) myopic participants in our study presented with occurrence of any type of peripheral retinal degeneration. LD was found to be the most prevalent peripheral retinal degeneration, present in about 20% ($n = 60$) of the participants, followed by WWOP (15.7%; $n = 47$), WWP (8.7%; $n = 26$), and CRA (8.3%; $n = 25$). We compared our results with those of previously done similar studies [Table 2].

Type of Study

Our study is an observational cross-sectional study, like most of the studies done previously to find the prevalence of peripheral retinal degenerations in myopic population. It was feasible to perform it in a period of 1-year duration, involve multiple variables together, and collect data on the whole study population at a single point of time.

Impact of Ethnicity

The prevalence of peripheral retinal changes due to myopia may vary among different populations and ethnicities. This may be due to the multiple genetic and environmental factors involved, which may result in a variable natural history of the condition among different populations. In a few studies, it has been suggested that Indians may have a lower incidence of Retinal detachment (RD) than Caucasians.[5,8] This variation may also occur due to differences in the structural and optical properties of the eye among different ethnicities.[14]

Chandra et al.[15] did a study on patients of two different ethnicities – European Caucasian (EC) and South Asian (SA). They found that SAs had higher prevalence of LD, more SE of refraction, higher severity of myopia, and greater mean AL compared to ECs ($P = 0.014$), and thus had a higher risk for RD.

Our study was done on North Indian myopic population. Studies have been done on Egyptian, Asian, Chinese, American, and Japanese myopic populations previously, and results have been compared in Table 2.

Distribution of Peripheral Retinal Degenerations in Different Age Groups

In our study, we found that there was a significant increase in the prevalence of LD and CRA with age. The prevalence of retinal break and retinal degeneration also increased with age and WWOP and WWP were seen more in younger age groups, but the results were not significant. With increasing age, several structural and functional changes occur in the posterior part of the eye. A study conducted with Optical coherence tomography (OCT) has shown thinning of retina with aging.[16] These anatomical variations, degenerative changes, and pathologic processes in myopic individuals with advancing age can be the reason for the lower prevalence of peripheral retinal degeneration in children compared to adults. Thus, these findings suggest a temporal relationship between age and development of peripheral retinal degenerations. This might explain the lower prevalence of retinal breaks (3.7%) and retinal detachment (0.7%) in our study, as we had less participants in the older age group, that is, 10–20 years ($n = 168$), 21–30 years ($n = 68$), and 31–40 years ($n = 64$). Similar findings

were seen in a study done by Chen et al.[9] Other studies done previously (Beijing Eye Study,[17] Shihpai Eye Study,[18] Blue Mountain Eye Study[19]) have also shown a trend of increased prevalence of pathologic myopia with age.

Gender Bias

There was no significant difference in the distribution of peripheral retinal degeneration in myopic males and females in our study. Similar outcomes were seen in the study done by Dhakal et al.[6] and in Blue Mountain Eye study[19] and Beijing Eye Study.[17] However, females were reported to have higher prevalence than males (2.2% vs. 1.2%) in elderly Japanese population in Hisayama study.[20] Ito-Ohara et al.[21] and Gozum et al.[5] also reported similar findings in myopic populations of Japan and Turkey, respectively. There are conflicting results on whether there are any sex differences in the prevalence of myopia, and currently, there is no credible biological argument to explain the differences in the prevalence between sexes observed in some studies.

Association of Peripheral Retinal Degenerations with AL

In our study, the prevalence of most of the peripheral retinal degenerations is significantly associated with increased AL. Tideman et al.[22] also observed in their study that risk of visual impairment associated with myopic degenerations was greater than 90% with AL ≥30 mm, compared to only 3.8% in AL of 24–26 mm. Similarly, Lam et al.[13] found a positive correlation between AL and paving stone degeneration. In their study, the prevalence of retinal holes was 6.4% in eyes with AL <30 mm and 30.0% in eyes with AL of ≥30 mm (Chi-squared test, $P = 0.006$). In a study done by Chen et al.,[9] increase in AL was found to be the only significant risk factor for peripheral retinal changes on multivariate analysis.

The type of axial elongation in high myopes has been hypothesized as another factor that could contribute to the development of peripheral retinal degenerations. A study done by Atchison et al.[23] demonstrated through magnetic resonance imaging (MRI) that myopic eyes tend to elongate more in length than in height and width. They grouped equatorial and posterior pole elongation of eyeball into a common pool termed "axial elongation" and found that more myopes exclusively fitted this model than the global expansion model. They proposed that asymmetrical globe elongation occurs in myopes due to restriction by bony orbit.

Association of peripheral retinal degenerations with grades of severity of myopia

Our study also established a significant increase in prevalence of peripheral retinal degeneration with increasing grade of myopia. The prevalence of LD increased significantly from 5.4% in mild myopes (-0.5 to -3.0 D) to 37% in severe myopes (<-10.0 D). Similarly, the prevalence of WWOP increased significantly from 6.3% in mild myopes to 32.6% in severe myopes. Similar trend was seen with other peripheral retinal degenerations also. Beijing Eye Study[17] also found similar results that the prevalence of myopic retinopathy significantly increased with increasing refractive error, from 3.8% in eyes with <-4.0 D to 89.6% in eyes with at least −10.0 D. The Hisayama study[20] also reported an increase in prevalence of pathologic lesions with increasing grade of myopia (myopic retinopathy increased from 0.3% in eyes with refractive error <−6.0 D to 36.8% in eyes with refractive error of at least −10.0 D).

Fundus Location

In our study, occurrence of peripheral retinal degenerations was more common in inferotemporal and superotemporal quadrants of fundus. LD, WWP, and snail-track degeneration were mostly seen in inferotemporal quadrant; WWOP and CRA were mostly seen in superotemporal quadrant. Similar findings were obtained in study done by Chen *et al.*,[9] where the occurrence of peripheral retinal degeneration was more commonly seen in the temporal quadrant of fundus.

Strengths and Limitations of Our Study

There are several strengths of our study, like inclusion of myopic population of all grades and severity, rather than including only high or pathologic myopia as done in a majority of previous studies. Inclusion of both eyes of myopic participants of a wide age group ranging from 10 to 40 years, which included children as well as young adults of both the sexes, provided a better and detailed analysis of the prevalence of peripheral retinal degeneration in myopic population.

The study had some limitations as well. Firstly, the sample size of myopic individuals was limited (300). Secondly, the study being a hospital-based study, only those patients who had come to hospital for some vision-related problem were included. Thirdly, few peripheral changes like chorioretinal atrophy develop later in life; but the use of data from 10 to 40 years age group in this study does not give insights on the overall proportion of myopic lesions in elderly population. Fourthly, a recent study done by Ken Hayashi *et al.*[24] showed that posterior vitreous degeneration (PVD) develops at a significantly younger age in highly myopic eyes, which can explain the early occurrence of PVD-related peripheral retinal changes in highly myopic patients. The documentation of PVD by swept-source OCT could have given an extra edge to our study.

Conclusion

The results of our study indicate the necessity for careful peripheral fundus examinations for all myopes, irrespective of age and degree of myopia, for early diagnosis and better management of visual-threatening complications like retinal detachment.

Documentation of AL should also be included in the routine evaluation process of myopic children, along with peripheral fundus examination to evaluate the pattern of increase in AL and for an early detection of progressive myopia.

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Conflicts of interest
There are no conflicts of interest.

References

1. Pan CW, Dirani M, Cheng CY, Wong TY, Saw SM. The age-specific prevalence of myopia in Asia: A meta-analysis. Optom Vis Sci 2015;92:258-66.

2. Holden BA, Fricke TR, Wilson DA, Jong M, Naidoo KS, Sankaridurg P, *et al*. Global prevalence of myopia and high myopia and temporal trends from 2000 through 2050. Ophthalmology 2016;123:1036-42.

3. Pierro L, Camesasca FI, Mischi M, Brancato R. Peripheral retinal changes and axial myopia. Retina 1992;12:12-7.

4. Tasman W. Peripheral retinal lesions. In: Myron Yanoff, Jay S. Duker, editors. Ophthalmology. Elsevier Saunders: China; 2014. p. 638-41.

5. Gozum N, Cakir M, Gucukoglu A, Sezen F. Relationship between retinal lesions and axial length, age, and sex in high myopia. Eur J Ophthalmol 1997;7:277-82.

6. Dhakal R, Goud A, Narayanan R, Verkicharla PK. Patterns of posterior ocular complications in myopic eyes of Indian population. Sci Rep 2018;8:13700.

7. Daniel WW, editor. Biostatistics: A Foundation for Analysis in the Health Sciences. 7th ed. New York: John Wiley & Sons; 1999.

8. Elnahry AG, Khafagy MM, Esmat SM, Mortada HA. Prevalence and associations of posterior segment manifestations in a cohort of Egyptian patients with pathological myopia. Curr Eye Res 2019;44:955-62.

9. Chen DZ, Koh V, Tan M, Tan CS, Nah G, Shen L, *et al*. Peripheral retinal changes in highly myopic young Asian eyes. Acta Ophthalmol 2018;96:e846-51.

10. Akbani MI, Reddy KR, Vishwanath K, Saleem M. Prevalence of peripheral retinal degenerations in the cases of myopia- A prospective study. Indian J Public Health Res Dev 2014;5:58. doi: 10.5958/j. 0976-5506.5.2.074.

11. Bansal AS, Hubbard GB 3rd. Peripheral retinal findings in highly myopic children<or=10 years of age. Retina 2010;30 (4 Suppl):S15-9.

12. Lai TY, Fan DS, Lai WW, Lam DS. Peripheral and posterior pole retinal lesions in association with high myopia: A cross-sectional community-based study in Hong Kong. Eye (Lond) 2008;22:209-13.

13. Lam DS, Fan DS, Chan WM, Tam BS, Kwok AK, Leung AT, *et al*. Prevalence and characteristics of peripheral retinal degeneration in Chinese adults with high myopia: A cross-sectional prevalence survey. Optom Vis Sci 2005;82:235-8.

14. Verkicharla PK, Suheimat M, Schmid KL, Atchison DA. Differences in retinal shape between East Asian and caucasian eyes. Ophthalmic Physiol Opt 2017;37:275-83.

15. Chandra A, Banerjee P, Davis D, Charteris D. Ethnic variation in rhegmatogenous retinal detachments. Eye (Lond) 2015;29:803-7.

16. Alamouti B, Funk J. Retinal thickness decreases with age: An OCT study. Br J Ophthalmol 2003;87:899-901.

17. Liu HH, Xu L, Wang YX, Wang S, You QS, Jonas JB. Prevalence and progression of myopic retinopathy in Chinese adults: The Beijing eye study. Ophthalmology 2010;117:1763-8.

18. Chen SJ, Cheng CY, Li AF, Peng KL, Chou P, Chiou SH, *et al*. Prevalence and associated risk factors of myopic maculopathy in elderly Chinese: The Shihpai eye study. Invest Ophthalmol Vis Sci 2012;53:4868-73.

19. Attebo K, Ivers RQ, Mitchell P. Refractive errors in an older population: The blue mountains eye study. Ophthalmology 1999;106:1066-72.

20. Asakuma T, Yasuda M, Ninomiya T, Noda Y, Arakawa S, Hashimoto S, *et al*. Prevalence and risk factors for myopic retinopathy in a Japanese population: The Hisayama study. Ophthalmology 2012;119:1760-5.

21. Ito-Ohara M, Seko Y, Morita H, Imagawa N, Tokoro T. Clinical course of newly developed or progressive patchy chorioretinal atrophy in pathological myopia. Ophthalmologica 1998;212:23-9.

22. Tideman JW, Snabel MC, Tedja MS, van Rijn GA, Wong KT, Kuijpers RW, *et al*. Association of axial length with risk of uncorrectable visual impairment for Europeans with myopia. JAMA Ophthalmol 2016;134:1355-63.

23. Atchison DA, Jones CE, Schmid KL, Pritchard N, Pope JM, Strugnell WE, *et al*. Eye shape in emmetropia and myopia. Invest Ophthalmol Vis Sci 2004;45:3380-6.

24. Hayashi K, Manabe S, Hirata A, Yoshimura K. Posterior vitreous detachment in highly myopic patients. Invest Ophthalmol Vis Sci 2020;61:33. doi: 10.1167/iovs. 61.4.33.