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Clinical Profile of posterior segment in high Myopia

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ABSTRACT

Background: Myopia is a growing global health concern, with prevalence surging, especially in East and Southeast Asia. The World Health Organization identifies high myopia as -5.00 diopter or less, carrying an elevated risk of irreversible blindness. In 2020, an estimated 2.6 billion people had myopia, projected to reach 4.7 billion by 2050, leading to a rise in complications like myopic maculopathy. This study, conducted in Nepal, where 47.16% of the population is myopic, aims to assess fundus and optic nerve changes in high myopia, examining associations with age, gender, axial length, and mean spherical error.

Methods: A prospective, cross sectional study was conducted by recruiting 98 high myopic eyes (defined as spherical equivalent of <-5.0 diopters (D) or axial length ≥ 26.00 mm). Colored Fundus photography was performed on viewing angle of 50^0 in different field of gazes following pupillary dilatation. Fundus photographs were graded by independent graders to evaluate for high myopic fundus and optic disc changes. Multinomial logistic regression was performed with axial length and mean spherical error as risk and myopic changes as dependent variable.

Results: In this study, tessellated fundus (57.1%) and peripapillary atrophy (40.8%) were the most common posterior segment changes in high myopic Nepalese subjects. High myopic features were seen in 45.9% of cases. Increase in axial length and mean spherical error was established as a risk factor for development of high myopic changes in the fundus.

Conclusions: In this study of the highly myopic Nepalese population visiting tertiary eye hospital, myopic changes such as tessellated fundus and peripapillary atrophy were frequent and were associated with axial length and mean spherical error.

Keywords: Degenerative myopia; high myopia; pathologic myopia; peripapillary atrophy; tessellated fundus.

INTRODUCTION

Myopia, defined as a significant global public health issue, is rapidly escalating, particularly in East and Southeast Asia.[1] The World Health Organization categorizes high myopia as -5.00 diopter (D) or less, linked to an elevated risk of irreversible blindness.[2] Estimated global myopia cases reached 2.6 billion in 2020, anticipated to surge to 4.7 billion by 2050, affecting nearly half of the world's population.[1,2] Consequently, complications like myopic maculopathy are expected to rise, encompassing a spectrum of changes based on the META-PM classification. The global burden is exacerbated by myopia presenting at younger ages, increasing the overall risk of reaching high myopia with associated complications. In Nepal, a hospital-based study reveals 47.16% myopia prevalence, with 6.56% classified as high myopia.[3]

This study aims to assess posterior segment changes in high myopic patients attending tertiary eye hospital in Nepal as well as exploring its associations with age, gender, axial length, and mean spherical error.

METHODS

This cross-sectional study adhered to the Declaration of Helsinki guidelines and was approved by the Institutional Review Board of the National Academy of Medical Sciences, Bir Hospital (Reference number:

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182/2079/80). This study was conducted from August 2021 to July 2022 at Nepal Eye Hospital and enrolled high myopic patients (spherical equivalent <-5.0D or axial length ≥ 26.00 mm) from the Out-patient, Pediatric Ophthalmology, and Retina clinic of Nepal Eye Hospital. The sample size was determined using the formula for cross-sectional survey, $n = (Z^2pq)/d^2$ where, n = desired sample size, Z= 1.96 at 95% confidence level, p= 0.0656and d = 0.05. The required minimum sample size was 94. Inclusion criteria were: age > 5 years, best-corrected visual acuity (BCVA) ≥1.0, spherical equivalent <-5.0D or axial length ≥ 26.00 mm, and no abnormalities beside myopic changes in slit lamp and fundus examinations. Exclusions comprised systemic diseases, syndromic associations with except myopia, ocular diseases (except ametropia), ocular trauma, prior eye surgery, previous laser refractive surgery, use of low-dose atropine, anti-myopia spectacles, anti-myopia multifocal soft contact lenses, and orthokeratology. The eye with the greater myopic magnitude was selected for the study.

Participants underwent a comprehensive ophthalmologic examination, including retinoscopy without cycloplegia, subjective refraction, best-corrected visual acuity (BCVA) assessment, axial length measurement, and Keratometry using Nidek 14101-M803-E2 Optical Biometer. Slit-lamp examination, binocular indirect ophthalmoscopy with scleral depression, and color fundus photography were conducted with Canon CF1 fundus camera (Canon Inc. (2014), Japan). Spherical equivalent refraction (SER) was calculated by adding spherical refraction and half the cylindrical refraction.

Fundus photography involved colour photograph mode with vieweing angle of 50^0. Several fields per eye, one centered at the optic disc, one at the fovea, and other in different fields of gazes were photographed, using Canon CF1 after pupillary mydriasis with 1% Tropicamide + 5% phenylephrine solution. High-resolution digital photos were stored and assessed by two masked vitreo-retinal surgeons (S.K and P.B) for evaluating myopic changes.

Statistical analysis employed SPSS (version 25.0; IBM, Chicago, USA). Continuous variables were presented as mean±standard deviation, and classification variables as frequency (%). Prevalence rates with 95% confidence intervals were described. Group comparisons utilized unpaired t-tests, ANOVA for normally distributed variables, and chi-squared tests for myopia prevalence differences. Multivariable logistic regression analyzed age, magnitude, and axial length relationships. P-values < 0.05 were considered statistically significant.

RESULTS

Ninety-eight eyes of high myopic subjects (50 males, 48 females) with a mean age of 20.36 ± 11.67 years (range: 5 to 65 years) were assessed, predominantly comprising individuals aged 15-25 years (Table 1). In this cohort, 43.9% (43 eyes) had axial lengths between 26-28mm. The mean spherical error for the participants was -9.28 ± 4.40D (range: -6.00 to -25.00D), with the majority having a mean spherical error between -6.00 to -9.00D. Table 1 provides a summary of the ocular features of the enrolled subjects.

Multiple fundus findings were noted in high myopic eyes, with the most common being tessellated fundus (57.1%), followed by White without pressure (20.4%) and lattice degeneration (12.2%) (Figure 1). Posterior

Table 1. Distribution of high myopic eye based on age. Sex, axial length and mean spherical error.

Based on Age and Sex				Based on axial length		Based on mean spherical error	
Age	Male	Female	Total	Axial Length (mm)	Frequency (%)	Mean Spherical Error (Diopters)	Frequency (%)
5-15	25	18	43 (43.8%)	<24	6 (6.1%)	-6.00 to -9.00	66 (67.3%)
15-25	12	14	26(26.5%)	24-26	35 (35.7%)	-9.00 to -12.00	18 (18.4%)
25-35	9	11	20 (20.4%)	26-28	43 (43.9%)	-12.00 to -15.00	6 (6.1%)
35-45	0	3	3 (3.1%)	28-30	8 (8.2%)	-15 to -18.00	1 (1.0%)
>45	4	2	6 (6.1%)	>30	6 (6.1%)	>-18.00	7 (7.1%)

Fundus and optic disc changes in eyes with high myopia

Table 2. Myopic Fundus and Optic disc Changes in High Myopes by Age , gender, axial length and mean spherical error.											
All	Tessellated Fundus	White Without Pressure	Lattice Degeneration	Viterous Denegeration	Posterior Staphyloma	Peripheral focal retinoschisis	Posterior Vitreous Detachment	Snail Track Degeneration	Tilted Disc	Peripapillary atrophy	Temporal crescent
98	56 (57.1%)	20 (20.4%)	12 (12.2%)	9 (9.3%)	5 (5.1%)	3 (3.1%)	3 (3.1%)	7 (7.1%)	30 (30.6%)	40 (40.8%)	2 (2%)
Age											
5-15 (N = 46)	24 (24.5%)	9 (9.2%)	5 (5.1%)	5 (5.2%)	2 (2%)	0	0	4 (4.1%)	8 (8.2%)	12 (12.2%)	2 (2%)
15-25 (N= 23)	15 (15.3%)	7 (7.2%)	3 (3.1%)	1 (1%)	0	3 (3.1%)	1 (1%)	0	10 (10.2%)	16 (16.3%)	0
25-35 (N = 20)	13 (13.3%)	4 (4.1%)	3(3.1%)	0	2 (2%)	0	1 (1%)	2 (2%)	9 (9.2%)	8 (8.2%)	0
35-45 (N = 3)	3 (3.1%)	0	0	0	0	0	1 (1%)	0	1 (1%)	3 (3.1%)	0
>45 (N = 6)	1(1%)	0	1 (1%)	3 (3.1%)	1 (1%)	0	0	1 (1%)	2 (2%)	1 (1%)	0
p-value	0.225	0.701	0.962	0.002	0.001	0.127	0.049	0.535	0.142	0.019	0.706
Gender											
Male (N= 50)	21 (21.4%)	10 (10.2%)	5 (5.1%)	5 (5.1%)	2 (2%)	0	0	0	11 (11.2%)	14 (14.3%)	2 (2%)
Female (N= 48)	35 (35.7%)	10 (10.2%)	7 (7.1%)	4 (4.1%)	3 (3.1%)	3 (3.1%)	3 (3.1%)	7 (7.1%)	19 (19.4%)	26 (26.5%)	0
p-value	0.002	0.918	0.489	0.775	0.613	0.073	0.073	0.005	0.059	0.008	0.162
Axial Length											
<24 (N = 6)	0	0	0	2 (2.0%)	0	0	0	0	1 (1.0%)	1 (1.0%)	0
24-26 (N= 35)	20 (20.4%)	8 (8.2%)	3 (3.1%)	2 (2%)	0	3 (.1%)	1 (1.0%)	1 (1.0%)	13 (13.3%)	19 (19.4%)	0
26-28 (N= 43)	24 (24.5%)	7 (7.1%)	7 (7.1%)	3 (.1%)	2 (2%)	0	0	5 (5.1%)	13 (13.3%)	11 (11.2%)	2 (2.0%)
28-30 (N= 8)	7 (7.1%)	4 (4.1%)	2 (2.0%)	2 (2.0%)	1 (1.0%)	0	2 (2.0%)	0	2 (2.0%)	6 (6.1%)	0
>30 (N= 6)	5 (5.1%)	1 (1.0%)	0	0	2 (2.0%)	0	0	1 (1.0%)	1 (1.0%)	3 (3.1%)	0
p[a]-value	0.013	0.166	0.409	0.093	0.011	0.234	0.001	0.383	0.750	0.015	0.625
OR (95% CI) p[b] - value	1.6 (1.18 to 2.15) 0.02	1.17 (0.91 to 1 51) 0.206	1.15 (0.85 to 1.55) 0.362	0.98 (0.67 to 1.43) 0.926	2.02 (1.27 to 3.22) 0.003	0.56 (0.23 to 1.38) 0.210	1.83 (1.11 -3.01) 0.017	1.17 (0.81 to 1.71) 0.383	0.98 (0.77 to 1.24) 0.872	1.11(0.88 to 1.31) 0.362	1.33 (0.74 to 2.41) 0.330
Mean Spherical Error											
-6.00 to -9.00 (N = 66)	33 (33.7%)	9 (9.2%)	6 (6.1%)	7 (7.1%)	0	3 (3.1%)	0	6 (6.1%)	19 (19.3%)	26 (26.5%)	0
-9.00 to -12.00 (N = 18)	12 (12.2)	5 (5.1%)	5 (5.1%)	1 (1.0%)	1 (1.0%)	0	1 (1.0%)	0	8 (8.2%)	5 (5.1%)	2 (2.0%)
-12.00 to -15.00 (N = 6)	3 (3.1%)	3 (3.1%)	1 (1.0%)	0	1 (1.0%)	0	1 (1.0%)	0	1 (1.0%)	4 (4.1%)	0
-15 to -18.00 (N = 1)	1 (1.0%)	1 (1.0%)	0	0	0	0	0	0	1 (1.0%)	1 (1.0%)	0
>-18.00 (N = 7)	7 (7.1%)	2 (2.0%)	0	1 (1.0%)	3 (3.1%)	0	1 (1.0%)	1 (1.0%)	1 (1.0%)	4 (4.1%)	0
p[a]-value	0.065	0.063	0.308	0.885	<0.001	0.723	0.010	0.385	0.180	0.358	0.106
OR (95% CI) p[b] - value	1.80 (1.16 to 2.80) 0.008	0.981 (0.77 to 1.24) 0.872	1.02 (0.64 to 1.63) 0.929	0.98 (0.56 to 1.70) 0.950	3.05 (1.57 to 5.90) 0.001	0.65 (0.17 to 2.42) 0.518	2.13 (1.07 to 4.23) 0.003	1.06 (0.59 to 1.90) 0.825	1.02 (0.73 to 1.43) 0.873	1.24 (0.90 to 1.71) 0.188	1.31 (0.53 to 3.19) 0.556

Muntinominal logistic regression with axial length and mean spherical error as risk factor and myopic fundus and optic disc changes as dependent variable; OR: Odd ratio; CL: Confidence Interval; p[q] : unadjusted p-value; p[b]: multinominal adjusted; p: value for x2 test

vitreous detachment occurred in 3.1%, and 5.1% showed posterior staphyloma. Peripheral focal retinoschisis was seen in three patients, and one had focal choroidal atrophy. Notably, lacquer cracks, sub-retinal or macular hemorrhage, retinal or foveal detachment, Fuch's Dystrophy, peripapillary intra-choroidal atrophy, myopic choroidal neovascular membrane, and macular retinoschisis were absent in this study.

Among 98 myopic patients, 76.53% exhibited optic disc changes, with peripapillary atrophy being the most common (40.8%), followed by tilted disc (30.6%). Optic disc pit was not observed in any patients.

Tessellated fundus (56/98; 57.1%) and peripapillary atrophy (40/98; 40.8%) were highly prevalent in all age group categories (Table 2), especially in patients within 15-25 age groups (15/23 and 16/23 respectively)Vitreous degeneration, posterior staphyloma and peripapillary atrophy increased in prevalence with increasing age (Table 2). In chi-square test of independence, significant difference was not observed for fundus changes across various age groups ($p = 0.225$), however significant difference was observed for optic changes across various age group, with a medium effect of the age groups ($x2 = 6.93$; $df = 5$; $\eta = 0.372$, $p = 0.019$). Differences in prevalence of fundus and optic nerve changes were noted with respect to gender. Compared to male, females had higher prevalence of tessellated fundus (35/48; 35.7%), and peripapillary atrophy (26/48; 26.5%).

In the chi-square test of independence, significant differences were observed for fundus changes and optic disc across various axial length groups, showing medium to large effects ($\eta = 0.360$, $p = 0.013$; $\eta = 0.354$, $p = 0.015$, respectively). Table 2 illustrates the association of axial length with fundus and optic disc changes, highlighting increased prevalence in eyes with axial length between 26-28mm (24.5%). Tessellated fundus was absent in patients with axial length below 24mm, while white without pressure was seen in those with axial length between 24-26mm. After adjusting for confounders (age and sex), multinomial logistic regression analysis revealed a 1.6 times increased risk of tessellated fundus for each mm increase in axial length. Similarly, the risks of developing posterior staphyloma and posterior vitreous detachment increased by 2.02 and 1.83 times, respectively, for each mm increase in axial length. Patients with axial length above 30mm exhibited paving stone degeneration, meridional retinal folds, and retinochoroidal coloboma.

In the chi-square test of independence, significant differences were noted for fundus changes and optic disc across various spherical equivalent intervals, with large and medium effects, respectively ($\eta = 0.520$, $p < 0.01$; $\eta = 0.366$, $p = 0.022$). Table 2 demonstrates the association of mean spherical error with fundus and optic disc changes, particularly in the -6.00 to -9.00D range, where higher prevalence was observed. In errors greater than or equal to -18.00D, various fundus and optic disc changes were evident. The risk of an increase in the prevalence of tessellated fundus, posterior staphyloma, and posterior vitreous detachment rose by 1.80, 3.05, and 2.13 times, respectively, with each diopter increase in mean spherical error. However, multivariate logistic regression analyses for comparing peripapillary atrophy and tilted disc to mean spherical error were not as revealing (Table 2).

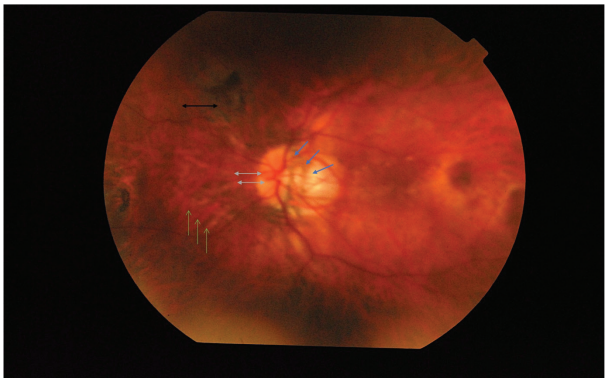

Figure 1: Myopic Changes in Posterior Pole; Blue arrow: Myopic Crescent with Peripapillary Atrophy, Grey double-arrow: Tilted Disc, Green arrow: Tessellated Fundus, Black double-arrow: Pigmented Lattice Degeneration

DISCUSSION

A refractive error less than -5.00 D is commonly defined as high myopia, associated with axial length greater than 26 mm. This study focused on fundus and optic disc changes in high myopic Nepalese eyes, revealing a prevalence of 45.9% for high myopic changes, with tessellated fundus and peripapillary atrophy being the most common. Comparable prevalence rates were reported in Indian (48.59%) and Chinese (42.3%) populations.[4-6] Tessellated fundus is an early sign of retino-choroidal changes in high myopia which results from globe elongation, causing retinal pigment epithelium hypoplasia. While choroidal thickness and Foveal avascular zone (FAZ) morphology were not evaluated, literature suggests thinning in the choroid and reduced FAZ area in myopes with tessellated fundus.[7] Posterior

staphyloma, observed in 5.1% of cases, is a component of myopic maculopathy associated with visual prognosis worsening. The proportion of high myopia with posterior staphyloma varies in literature from 0.7 to 32% in various studies.[8,9] In our study, we have found the prevalence of lattice degeneration to be 12.2%. Presence of lattice degeneration in myopic fundus increases the tendency of retinal detachment to develop in myopic eyes which is often sight threatening in nature resulting in irreversible visual impairment. Peripapillary atrophy was seen in 40.8%, acting as a predisposing factor to chorioretinal atrophy in highly myopic subjects. Its expansion indicates myopia progression.[10] Distinguishing myopic and glaucomatous changes in peripapillary atrophy is crucial; myopia presents absence of Bruch's membrane at the atrophic region (gamma zone). Disc tilt and temporal crescent, observed in 30.6% and 2% of myopic eyes respectively, are hallmarks of myopic optic disc due to axial elongation.

Age, axial length, and mean spherical error are established risk factors for myopia progression. In our study, both axial length and mean spherical error were consistently associated with fundus and disc changes. The frequency of tessellated fundus increased with higher axial length (Adjusted OR 1.6) and mean spherical error (Adjusted OR 1.80), aligning with findings by Haarman et al.[11] The risk of posterior staphyloma also rose by 2.02 (95% CI 1.27 - 3.22) with increased axial length and mean spherical error (Adjusted OR 3.05). Across age groups, we observed an escalating frequency of tessellated fundus and peripapillary atrophy, intensifying with age. Although we didn't collect myopia duration data, we believe fundus and disc changes correlate with myopia duration in the Nepalese population. Sex influenced the prevalence of tessellated fundus, tilted disc, and peripapillary atrophy, with higher occurrences in females. Management strategies included prophylactic laser treatment for eyes with retinal detachment-predisposing lesions and patient complaints of flashes and floaters. Patients with posterior staphyloma were closely monitored, receiving genetic counseling and education on danger signs and symptoms.

Our study provides valuable insights into myopia-related changes in the fundus and optic disc among the Nepalese population. However, being single centered hospital-based with a smaller sample size, generalizing our findings to a larger population may be limited. The use of colored fundus photography lacks a stereoscopic view, potentially missing significant details. Furthermore, the fundus camera we utilized had a limited field of view of 50^0 in a single image captured, and hence the use of wide field photography is recommended for coverage of peripheral pathology in these cases.. Our cross-sectional design doesn't document the temporal sequence of myopic changes, and optic disc tilt was not quantitatively assessed. Future studies with larger cohorts, long-term follow-up, and advanced wide-field technologies are recommended. Exploring the impact of myopia on quality of life and its association with the degree of myopia requires further investigation. Emphasizing early diagnosis and prompt treatment is crucial, given myopia's potential to impair vision significantly.

CONCLUSIONS

There is strikingly high prevalence of posterior segment changes in high myopic eyes, the most common being tessellated fundus and peripapillary atrophy. The pattern of myopic changes in the Nepalese eyes are consistent with that of other reported populations. Prevalence of myopic fundus changes increases with increase in age, axial length and mean spherical error. Fundus changes in myopes are often sight-threatening, hence it is very important to study these aspects to timely diagnose, refer and intervene the pathological changes to prevent permanent irreversible sight loss.

CONFLICT OF INTEREST

The authors declare no conflict of interests.

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