Original Article/นิพนธ์ต้นฉบับ

Ocular Morbidity of Myopia at Ramathibodi Hospital

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Abstract

Objective: To study the clinical characteristics of ocular morbidity of myopia at Ramathibodi Hospital.

Design: Retrospective cohort study

Methods: The medical records of 120 Thai patients (40 subjects in each of 3 groups- mild, moderate, and high myopia based on American Optometric Association definition) were reviewed. Prevalence of myopia-related retinal, optic disc changes and other morbidities (cataract, glaucoma, and strabismus) were compared among 3 groups.

Results: A total 120 subjects aged 20-80 years (mean age, 44.19 ± 14.98) with more than or equal to - 0.50 D of myopia were participated in our study and 51.6% were male. Fundus pallor and tessellation (100%), peripapillary atrophy (100%), and optic disc tilt (15%) were very common findings in high myopic group comparing to the other groups. Additional major pathologic findings in high myopic group were posterior vitreous detachment (10%) and posterior staphyloma (15%). Macular choroidal neovascularisation (5%) and Forster-Fuchs' spot (2.5%), disc tilt (10%), peripheral retinal lesions such as lattice degeneration (7.5%) and retinal break (7.5%) were also found only in high myopic group ($p < 0.05$). Foveoschisis, white without pressure, pigmentary, and paving stone degenerations were rarely seen. The percentage of primary open angle glaucoma (7.5%), ocular hypertension (5%), steroid induced glaucoma (5%) and subcapsular cataract (12.5%) observed in this study were significantly higher in high myopic group, compared to the other groups ($p < 0.05$). Prevalence of staphyloma and chorioretinal atrophy increased with the increase of age, myopic refractive error, and axial length (AL) (all; $p < 0.001$). In multivariate adjusted logistic regression analysis, the prevalence of staphyloma increased by 2.16 times for each diopter of myopia ($p < 0.001$). Similarly, the prevalence of chorioretinal atrophy increased by 1.68 times for each diopter of myopia ($p < 0.001$). The prevalence of posterior staphyloma increased by 2.58 times for each 1 mm increase in AL ($p < 0.001$). Likewise, the prevalence of chorioretinal atrophy ($p < 0.001$) increased by 3.13 times for each 1 mm increase in AL.

Conclusions: Staphyloma and chorioretinal atrophy are the most common pathological findings and the important causes of visual loss among Thai patients with high myopia. Morbidity of myopia was dependent on the duration of disease, age, degree of refractive error, and ALof each individual. High-risk patients who are elderly with severe myopia should be identified for regular screening and early management. **Thai J Ophthalmol 2013; July-December 27(2): 94-106.**

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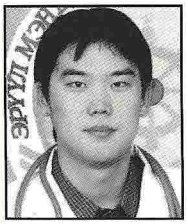
Original Article/นิพนธ์ต้นฉบับ

พยาธิสภาพทางตาของภาวะสายตาสั้นในโรงพยาบาลรามาธิบดี



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บทคัดย่อ

วัตถุประสงค์: เพื่อศึกษาความชุกและลักษณะทางคลินิคของพยาธิสภาพทางตาในภาวะสายตาสั้นที่โรงพยาบาลรามาธิบดี

ระเบียบวิธีการวิจัย: การศึกษาวิจัยย้อนหลัง

วิธีการ: รวบรวมข้อมูลผู้ป่วย 120 คนจากเวชระเบียน แบ่งเป็น 3 กลุ่ม กลุ่มละ 40 คน ตาม American Optometric Association definition คือ mild, moderate, และ high myopia แล้วนำข้อความชุกของพยาธิสภาพของจอประสาทตา ขั้วประสาทตา และอื่นๆ เช่น ต้อกระจก ต้อหิน และภาวะตาเขมาเปรียบเทียบกันระหว่าง 3 กลุ่ม

ผลการศึกษา: ผู้ป่วยทั้งหมดมีอายุอยู่ระหว่าง 20-80 ปี (เฉลี่ย 44.19 ± 14.98 ปี) เป็นผู้ชาย 51.6% และผู้ป่วยทั้งหมดมีภาวะสายตาสั้นมากกว่าหรือเท่ากับ - 0.50 D โดยใน high myopic group จะพบ fundus pallor and tessellation (100%), peripapillary atrophy (100%) และ optic disc tilt (15%) มากกว่าผู้ป่วยในกลุ่มอื่น และมีพยาธิสภาพอื่นๆซึ่งที่พบได้บ่อยคือ posterior vitreous detachment (10%) และ posterior staphyloma (15%) ส่วน macular choroidal neovascularisation (5%), Forster-Fuchs' spot (2.5%), disc tilt (10%), peripheral retinal lesions เช่น lattice degeneration (7.5%) และ retinal break (7.5%) พบเฉพาะใน high myopic group ($p < 0.05$) ส่วน foveoschisis, white without pressure, pigmentary และ paving stone degenerations พบได้น้อยมากในการศึกษานี้ ซึ่งอาจเนื่องจากจำนวนผู้ป่วยในการศึกษานี้มีน้อย และ primary open angle glaucoma (7.5%), ocular hypertension (5%) และ steroid induced glaucoma (5%) พบใน high myopic group ($p < 0.05$) เช่นกัน นอกจากนี้ความชุกของ subcapsular cataract พบมากใน high myopic group (12.5%) อย่างมีนัยสำคัญทางสถิติ ความชุกของ staphyloma and chorioretinal atrophy เพิ่มขึ้นเมื่อมีอายุ ภาวะสายตาสั้น และ axial length เพิ่มขึ้น (all; $p < 0.001$) โดยพยาธิสภาพของสายตาสั้นขึ้นกับ ระยะเวลาของโรค อายุที่มากขึ้น ระดับของความผิดปรกติของค่าสายตา และความยาวของ axial length ความเสี่ยงของ staphyloma จะเพิ่มขึ้น 2.16 เท่าในแต่ละ diopter ที่เพิ่มขึ้นของค่าผิดปรกติของสายตาสั้น ($P < 0.001$) เช่นเดียวกับ chorioretinal atrophy โดยมีความเสี่ยงเพิ่มขึ้น 1.68 เท่าในแต่ละ diopter ที่เพิ่มขึ้นของค่าผิดปรกติของสายตา สั้น ($P < 0.001$) และ multivariate adjusted logistic regression analysis พบว่าแต่ละ 1 มิลลิเมตรที่เพิ่มขึ้นของ axial length จะเพิ่มความเสี่ยงของ posterior staphyloma 2.58 เท่า ($P < 0.001$) และ chorioretinal atrophy เพิ่มขึ้น 3.13 เท่า ($P < 0.001$)

สรุป: Staphyloma and chorioretinal atrophy เป็นพยาธิสภาพที่พบมากที่สุดในผู้ป่วยไทยที่มี high myopia และเป็นสาเหตุสำคัญของการสูญเสียการมองเห็นใน high myopia และในทางคลินิก จักษุแพทย์ควรเฝ้าระวังพยาธิสภาพที่สำคัญของภาวะสายตาสั้นเมื่อผู้ป่วยอายุมากขึ้นหรือมีค่าสายตาสั้นที่ผิดปรกติมาก โดยการตรวจคัดกรองอย่างสม่ำเสมอและรักษาตั้งแต่ต้น **จักษุเวชสาร 2556; กรกฎาคม-ธันวาคม 27(2): 94-106.**

ผู้นิพนธ์ทั้งหมดไม่มีส่วนเกี่ยวข้องหรือผลประโยชน์ใดๆ กับผลิตภัณฑ์ที่ได้กล่าวอ้างถึงในงานวิจัยนี้

ภาควิชาจักษุวิทยา คณะแพทยศาสตร์โรงพยาบาลรามาธิบดี มหาวิทยาลัยมหิดล

The World Health Organization (WHO) introduced the global initiative for the elimination of avoidable blindness by the year 2020, known as "Vision 2020." Five conditions were chosen as immediate priorities: cataract, trachoma, onchocerciasis, childhood blindness, and refractive error.[1] WHO estimates that 153 million people worldwide live with visual impairment due to uncorrected refractive errors. High myopia is refractive error of at least 6 diopters (D) and axial length (AL) of greater than 25.5 mm or associated with globe elongation.[2-4] Pathologic myopia defined as presence of a spectrum of myopia-related retinal and optic disc changes, is a leading cause of visual impairment and blindness in Asian countries. The socioeconomic impact of blindness and visual impairment from myopia and high myopia is considerable, as it typically affects individuals during their productive years.[5] In Thailand, three national surveys of blindness were done in 1981, 1984 and 1994; the prevalence of blindness was shown to be 1.14%, 0.56% and 0.31%. Refractive errors were not included in the cause of blindness and low vision previously. In the fourth national survey of blindness, low vision and visual impairment in Thailand, conducted in 2006, refractive errors causing visual impairment were included in the questionnaire and eye examination. The survey was done by using the sample groups that were a stratified, cluster random sampling representing the whole country. Using the epidemiologic definition, the prevalence rates were determined for myopia, hyperopia and emmetropia and found to be 12.74%, 3.44% and 83.82% respectively.[6]

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High myopia is known to be a risk factor and progression factor for several ocular diseases. Some of retinal lesions may be associated with severe irreversible visual loss,therefore, it is important for clinicians to be aware of the retinal pathologies in high myopia. The risk factors for myopia include higher education, urban residential status, higher income, professional occupation, and increased near work. However, the underlying explanation for the worsening trend of myopia prevalence and severity is poorly understood and is likely complex and multi-factorial, given that East Asian countries with high myopia have similar socio-economic demographic risk factors as in the West. Pathologic myopia typically progresses with increasing age and higher degrees of myopia. Only few studies have evaluated the pattern of pathologic myopia lesions and associations with axial length and refractive error. Our aim is to study the pattern of myopia-related morbidity in Thai patients with myopia and correlate these findings with age, degree of refractive error and axial length.

Patients and methods

Approval was obtained from the Ethical Clearance Committee on Human Rights Related to Research involving Human Subjects of the Faculty of Medicine Ramathibodi Hospital, Mahidol University to perform this retrospective study. The medical records of 120 patients (40 subjects in each of 3 groups- mild, moderate, and high myopia based on American Optometric Association definition) seen in Department of Ophthalmology, Faculty of Medicine, Ramathibodi hospital, Mahdiol University between 2005-2013 with a minimum follow-up of 5 years were reviewed.

In our study, Thai adults aged over 20 years old, with more than or equal to - 0.50 D and underwent full ophthalmic examination were included. All subjects underwent a full ophthalmic evaluation in-

cluding visual acuity testing, refraction, intraocular pressure measurement with Goldmann applanation tonometry, dilated fundus examination with stereoscopic biomicroscopy of the optic nerve head under slit-lamp, indirect ophthalmoscopy, and A-scan ultrasound biometry. Additional tests such as optical coherence tomography (OCT) and fundus fluorescent angiography (FFA) were done if needed. We selected the participants based on American Optometric Association definition, in which myopia was measured in diopters by the strength or optical power of a corrective lens that focuses distant images on the retina and classified by degree or severity into 3 groups (mild, moderate, and high myopia). (Table 1)

Exclusion criteria of our study were as follows:.

1. Systemic diseases (diabetes mellitus and arterial hypertension)
2. Genetic diseases which had an association with high myopia
   - Down syndrome
   - Stickler syndrome
   - Marfan syndrome
   - Prematurity
   - Noonan syndrome
   - Ehlers-Danlos syndrome
   - Pierre-Robin syndrome
3. Refractive myopia
   - Keratoconus etc.
4. Induced myopia
5. History of prematurity
6. Previous ocular disease
7. Eyes with media opacity such as corneal scar or cataract obscuring

Refraction was refined by certified optometrist (Rattanawadee Thongruay, MA). Subjects' best-corrected visual acuity in logMAR scores was recorded. Spherical equivalent (SE) was calculated as the sum of the spherical power and half of the cylindrical power. The ocular biometry (IOL Master, Carl Zeiss Meditec AG, Jena, Germany) was done for axial length measurements. Simultaneous stereoscopic fundus photography was taken by Nidek 3Dx camera.

One eye per subject was chosen based on the highest myopic refractive error. We examined the association of pathologic myopia findings with age, sex, SE and AL. The relationship was assessed using the x^2 test (Fisher exact test) or analysis of variance. SE and AL were also analyzed as continuous variables. Multivariate linear regression and multivariate logistic regression were performed to

Table 1. International Classification of Diseases (ICD-10) of myopia

Parameters	Type of Classification
Degree	• Low myopia (< - 3.00 D) • Medium myopia (-3.00 - < 6.00 D) • High myopia (≥ - 6.00 D)
Age of onset	• Early adult-onset myopia (20-40 years of age) • Late adult-onset myopia (> 40 years of age)
Axial length	• ≥ 26.5 mm • < 26.5 mm

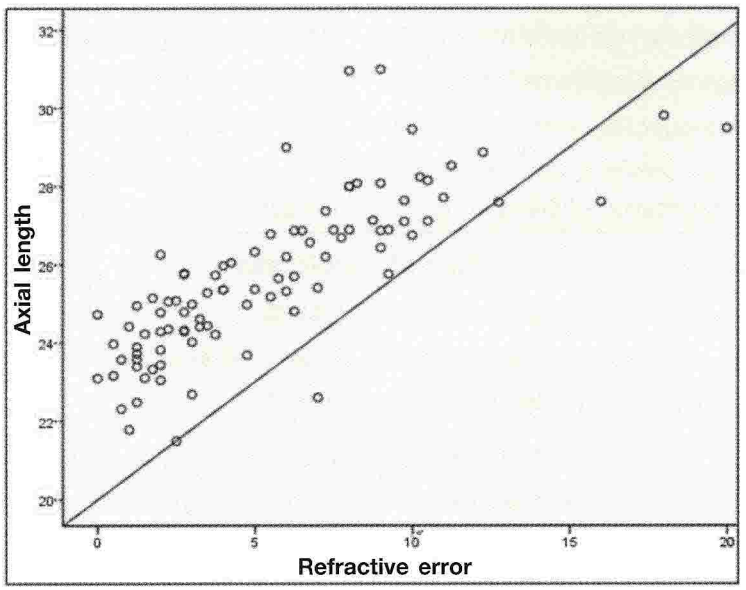
determine the associations between pathologic myopia findings and SE or AL, with the former as a dependent variable and the latter as independent variables, adjusted for confounders. Two-tailed P values of <0.05 were considered statistically significant. SPSS 18.0 version (IBM Corporation, College Station, Texas, USA) was used for all statistical analyses.

Results

A total 120 subjects aged 20-80 years (mean age, 44.19 ± 14.98) with more than or equal to - 0.50 D of myopia were participated in our study and 51.6% were male. The eye with the highest magnitude of myopic refractive error was used for analyses. (Table 2,3, and4) It shows subject distribution with respect to refractive error (< -3 D, -3 to < -6.00 D and ≥ -6 D) and age (20-40 years, 40-49 years, 50-59 years, and ≥ 60 years) (p <0.05). Sex did not differ with respect to degree of myopia.

Table 2. Distribution of myopia based on age, sex, BCVA, refractive error and axial length

Parameters	Severity degree of myopia			
	Mild	Moderate	High	95% CI
Gender	40	40	40	0.87
female (persons)	22	17	19	
male (persons)	18	23	21	
Age (mean ± SD)	44.12 ± 15.26	44.0 ± 15.72	44.47 ± 13.96	0.68
BCVA logMAR	0.09 ± 0.035	0.11 ± 0.3	0.19 ± 0.04	0.045
Refractive error	1.67 ± 0.14	4.13 ± 0.21	8.4 ± 0.54	0.032
Axial length	23.91 ± 1.21	25.10 ± 0.91	27.40 ± 1.58	0.044



Graphic 1. *Distribution of axial length and refractive error*

Table 3. Ocular Morbidities Among Thai Adults With Myopia

Morbidity	Posterior staphyloma N	n%	Chorioretinal atrophy N	n%	Lacquar crack N	n%	Macular CNV N	n%	Macular hemorrhage N	n%	Forster–Fuchs' spot N	n%	Foveoschisis N	n%	Macular hole N	n%
Posterior pole chorioretinal lesions																
All	120	8/6.66	120	3/2.50	120	0	120	3/2.50	120	0	120	1/0.83	120	0	120	4/3.33
Age (y)																
20-40	32	0	32	0	32	0	32	0	32	0	32	0	32	0	32	0
40-49	27	1/3.70	27	0	27	0	27	0	27	0	27	0	27	0	27	1/3.70
50-59	29	2/6.89	29	2/6.89	29	0	29	2/6.89	29	0	29	0	29	0	29	2/6.89
60 ≤	32	5/15.6	32	1/3.12	32	0	32	1/3.12	32	0	32	1/3.12	32	0	32	1/3.12
P trend	0.042		0.021		-		0.021		-		< .001		-		0.045	
Sex																
Male	62	5/8.0	62	2/3.22	62	0	62	1/1.61	62	0	62	1/1.61	62	0	62	2/3.22
Female	58	3/5.17	58	1/1.72	58	0	58	2/3.45	58	0	58	0	58	0	58	2/3.44
P value	0.12		0.23		-		0.09		-		-		-		0.42	
Spherical Equivalent																
-0.50- < -3.00 D	40	0	40	0	40	0	40	0	40	0	40	0	40	0	40	0
-3.00- < 6.00 D	40	0	40	0	40	0	40	0	40	0	40	0	40	0	40	1/2.50
-6.00 D ≥	40	8/20.0	40	3/7.50	40	0	40	3/7.50	40	0	40	1/2.50	40	0	40	3/7.50
P trend	< 0.001		<0.001		-		<0.001		-		<0.001		-		0.021	
Axial length																
26.5 mm ≥	81	1/1.23	81	0	81	0	81	0	81	0	81	0	81	0	81	1/1.23
26.5 mm <	39	7/17.9	39	3/7.50	39	0	39	3/7.69	39	0	39	1/2.56	39	0	39	3/7.69
P value	<0.001		<0.001		-		<0.001		-		<0.001		-		<0.001	

	Pigment periphery degeneration N	n%	White without pressure N	n%	Lattice degeneration N	n%	Peripheral retinal hole or break N	n%	Retinal detachment N	n%	Posterior vitreous detachment N	n%	Peripapillary atrophy N	n%	Tilted disc N	n%
Peripheral retinal lesions																
All	120	4/3.33	120	0	120	4/3.33	120	3/2.50	120	0	120	8/6.66	120	62/51.7	120	6/5.0
Age (y)																
20-40	32	0	32	0	32	1/3.13	32	1/3.13	32	0	32	0	32	11/34.4	32	1/3.13
40-49	27	0	27	0	27	0	27	0	27	0	27	0	27	13/48.2	27	2/7.40
50-59	29	2/6.89	29	0	29	2/6.89	29	1/3.44	29	0	29	3/10.3	29	18/62.1	29	2/6.89
60 ≤	32	2/6.25	32	0	32	1/3.13	32	1/3.13	32	0	32	5/15.6	32	20/62.5	32	1/3.13
P trend	0.032		-		0.021		0.49		-		0.04		0.12		0.23	

Table 3. Ocular Morbidities Among Thai Adults With Myopia *(cont.)*

Morbidity	Posterior pole chorioretinal lesions																	
	Posterior staphyloma		Chorioretinal atrophy		Lacquar crack		Macular CNV		Macular hemorrhage		Forster–Fuchs' spot		Foveoschisis		Macular hole	
	N	n%	N	n%	N	n%	N	n%	N	n%	N	n%	N	n%	N	n%
Sex																
Male	62	5/8.0	62	0	62	2/3.22	62	1/1.61	62	0	62	5/8.06	62	33/53.2	62	4/6.45
Female	58	3/5.17	58	0	58	2/3.44	58	2/3.45	58	0	58	3/5.17	58	29/50.0	58	2/3.44
P value	0.12		-		0.42		0.09		-		0.12		0.56		0.29	
Spherical Equivalent																
-0.50- < -3.00 D	40	0	40	0	40	0	40	0	40	0	40	0	40	2/5.0	40	0
-3.00- < 6.00 D	40	0	40	0	40	1/2.50	40	0	40	0	40	2/5.0	40	20/50.0	40	0
-6.00 D ≥	40	4/10.0	40	0	40	3/7.50	40	3/7.50	40	0	40	6/15.0	40	40/100	40	6/15.0
P trend	<0.001		-		0.021		<0.001		-		0.029		0.019		<0.001	
Axial length																
26.5 mm ≥	81	0	81	0	81	0	81	0	81	0	81	1/1.23	81	23/28.4	81	0
26.5 mm <	39	4/10.25	39	0	39	4/10.25	39	3/7.69	39	0	39	7/17.9	39	39/100	39	6/15.38
P value	<0.001		-		<0.001		<0.001		-		<0.001		0.09		<0.001	

	Glaucoma						Cataract									
	POAG		OHT		Steroid induced		Cortical		Nuclear		PSC		Mixed		Strabismus	
All	120	4/3.33	120	2/1.67	120	2/1.67	120	3/2.50	120	16/13.3	120	6/5.0	120	4/3.33	120	2/1.67
Age 20-40	32	0	32	1/3.13	32	1/3.13	32	1/3.13	32	0	32	0	32	0	32	0
40-49	27	0	27	1/3.70	27	1/3.70	27	0	27	3/11.1	27	0	27	0	27	1/3.70
50-59	29	2/6.89	29	0	29	0	29	1/3.44	29	6/20.6	29	2/10.3	29	1/3.45	29	1/3.45
60 ≤	32	2/6.25	32	0	32	0	32	1/3.13	32	7/21.8	32	4/15.6	32	3/9.37	32	0
P trend	0.032		0.056		0.051		0.49		0.045		0.044		0.034		0.061	
Sex																
Male	62	2/3.22	62	1/1.61	62	1/1.61	62	1/1.61	62	9/14.5	62	4/6.45	62	2/3.22	62	1/1.61
Female	58	2/3.44	58	1/1.72	58	1/1.72	58	2/3.45	58	7/12.0	58	2/3.44	58	2/3.44	58	1/1.72
P value	0.56		0.49		0.49		0.09		0.46		0.12		0.56		0.49	
Spherical Equivalent																
-0.50- < -3.00 D	40	0	40	0	40	0	40	2/5.0	40	4/10	40	0	40	1/5.0	40	0
-3.00- < 6.00 D	40	1/2.5	40	0	40	0	40	1/2.5	40	6/15	40	1/2.5	40	2/50.0	40	0
-6.00 D ≥	40	3/7.5	40	2/5.0	40	2/5.0	40	0	40	6/15	40	5/12.5	40	1/100	40	2/5.0
P trend	0.021		<0.001		<0.001		0.09		0.16		0.029		0.12		<0.001	
Axial length																
26.5 mm ≥	81	0	81	0	81	0	81	2/2.46	81	10/12.3	81	1/1.23	81	3/3.70	81	0
26.5 mm <	39	4/10.25	39	2/5.12	39	4/10.25	39	1/2.56	39	6/15.4	39	5/12.82	39	1/2.56	39	2/5.12
P value	<0.001		<0.001		<0.001		0.21		0.23		<0.001		0.09		<0.001	

The most common high myopic fundus finding was staphyloma (8/40; 20.0%), followed by posterior vitreous detachment (6/40; 15.0%). The incidence of macular hole is 3/40 (7.5%) in high myopia, 1/40 (2.5%) in moderate myopia, and chorioretinal atrophy 3/40 (7.5%) in high myopia, but no incidence in moderate and mild myopic groups ($p < 0.001$) (Table 3). The most common disc finding associated with high myopia were fundus pallor and tessellation (40/40; 100%), peripapillary atrophy (40/40; 100%), and optic disc tilt (15/40; 37.5%). However, there was no incidence of tilted disc in moderate and mild myopic groups ($p < 0.001$). In our study, only 2 subjects (5.0%) had definite choroidal neovascularization (CNV) with macular hemorrhage in high myopic group ($p < 0.001$).

In our study the peripheral retinal lesions such as lattice degeneration (3/40; 7.5%) and retinal break (3/40; 7.5%) was found in only high myopic group ($p < 0.05$). One case of Forster's Fuchs spot was seen in eye with the more severe myopic SE. Lacquer crack, macular hemorrhage, foveoschisis, and peripheral myopic retinopathy such as white without pressure and rhegmatogenous retinal detachment were not observed in our study.

The incidence of posterior subcapsular cataract was significantly different in high myopia (4/40; 10%), moderate myopia (1/40; 2.5%) and mild myopia (1/40; 2.5%). Incidence of glaucoma was significantly higher in high myopia comparing to the other groups ($p < 0.001$). In our study, primary open angle glaucoma (3/40; 7.5%); ocular hypertension (2/40; 5.0%) and steroid induced glaucoma (2/40; 5.0%) were found in high myopic group ($p < 0.05$). In our study myopic strabismus fixus (2 esotropia) cases were found in only high myopic group ($p < 0.05$).

Prevalence of staphyloma and chorioretinal atrophy increased with the increase of age, myopic refractive error, and axial length (AL) (all; $p < 0.001$). In multivariate adjusted logistic regression analysis, the prevalence of staphyloma increased by 2.16 times for each diopter of myopia ($p < 0.001$). Similarly, the prevalence of chorioretinal atrophy increased by 1.68 times for each diopter of myopia ($p < 0.001$). The prevalence of posterior staphyloma increased by 2.58 times for each 1 mm increase in AL ($p < 0.001$). Likewise, the prevalence of chorioretinal atrophy ($p < 0.001$) increased by 3.13 times for each 1 mm increase in AL.

Table 4. Summary of Ocular Morbidities Among Thai Adults With Myopia

Complications/ co- morbidity	Severity degree of myopia			95% CI
	Mild (n/%)	Moderate (n/%)	High (n/%)	
Posterior pole chorioretinal lesions	0/0	3/7.5	16/40.0	0.021
Peripheral retinal lesions	0/0	3/12.0	22/55.0	0.029
Cataract	8/20.0	11/27.5	12/30.0	0.871
Glaucoma, OHT	0/0	2/5.0	7/17.5	0.034
Strabismus	0/0	0/0	2/5.0	< 0.001

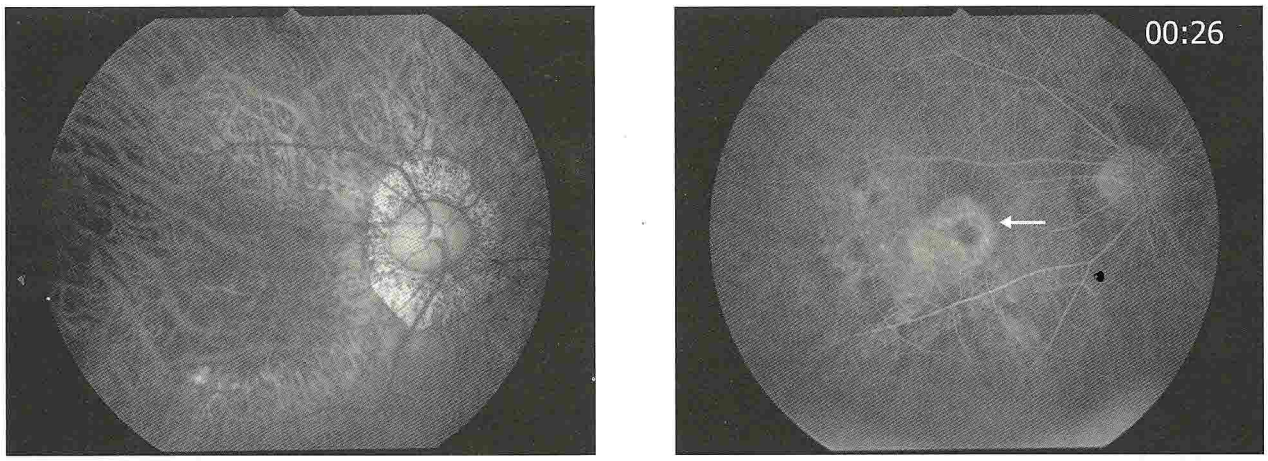


Figure 1. *A 38-year-old man. Best corrected visual acuity was 20/150, and the refractive error was -11.0 diopters in the right eye.*

A. The right fundus photo shows the myopic tessellated fundus and peripapillary atrophy. There is no significant pathology seen in macula in this fundus photo. B. Additional investigation of FFA in right eye revealed a choroidal neovascularization (hyperfluorescence) with macular hemorrhage in the center (blockage of fluorescence; arrow).

Discussion

Among Thai adults with high myopia, the fundus pallor and tessellation, peripapillary atrophy, and optic disc tilt are common disc findings. The other major pathologic findings are posterior vitreous detachment (10.0%) and posterior staphyloma (15.0%). Posterior vitreous detachment was found in 12.5% in a case series of patients with high myopia, 60.7% in patients with axial length > 30 mm.[7] No myopic crescent was present if the axial length was 21 mm, 75% of the eyes had myopic crescents if the axial length was 25 mm to 29 mm, and 100% of the eyes had myopic crescents if the axial length was more than 29 mm.[8] We found that the prevalence of staphyloma increased with respect to the axial length, age, and myopic refractive error ($p < 0.001$). Posterior staphyloma was observed in 8 subjects (8/40; 20.0%) with refractive error greater than 6.0 D, while there was no such finding in mild and moderate myopia.

Chorioretinal atrophy is an area of well-circumscribed chorioretinal degeneration in the posterior pole and more importantly, it is a sight threatening pathology in myopia. It was seen in 3 subjects (7.5%) in high myopic group ($p < 0.001$). This number is lower than in the Japanese study, where chorioretinal atrophy was found in 163 eyes (20.2%).[9] Chorioretinal atrophy was also more prevalent in older adults and in adults with more severe refractive error and longer axial length in our study ($p < 0.001$). In the Beijing Eye Study, increased prevalence of myopic chorioretinopathy was associated with increasing myopic refractive error, and a significant rate of progression was seen even at 5 years.[10]

The staphyloma was reported to be a causative factor for chorioretinal atrophy.[11] Posterior pole staphyloma has been reported to be the most common type of staphyloma among patients with high myopia. The morphological classification of poste-

rior staphylomatous findings were described by Curtin[12] as nasal, macula-centered, disc-centered and tiered staphylomas. It is a localized ectasia of the sclera, choroid, and retinal pigment epithelium that can be of variable size and involve different aspects of the posterior fundus. Vision progressively deteriorates in eyes with staphylomas that are macula-centered because of the progressive thinning of the choroids and retinal pigment epithelium in the macula. The correlation between posterior staphyloma and chorioretinal atrophy was high, possibly because of the small number of cases in our study.

Myopic choroidal neovascularization has been reported to occur in up to 10% in those with myopia12 and up to 40.7% in high myopia.[13] In our study, only 2 subjects (5.0%) had definite choroidal neovascularization (CNV) with macular hemorrhage in high myopic group. The rate of CNV was much higher in the Japanese study, in which 91 eyes (11.3%) with more severe myopic refractive error had CNV at initial presentation.[14] The possible explanation was that early CNV could have been missed in this study because the fundus photographs were examined without the aid of fluorescein angiography.

One case of Forster's Fuchs spot was seen in eye with more severe myopic SE. Forster-Fuchs' spot (1/2.5%) was present in a few individuals among the high myopic patients. This might result from a transient nature of Forster Fuch's spot, which typically follows active CNV and could later be enveloped by chorioretinal atrophy. Lacquar crack and foveoschisis are relatively rare complications of high myopia. Forster- Fuchs spot is a raised, circular, pigmented lesion at the macula developing after a subretinal haemorrhage has absorbed. In highly myopic eyes, the Forster-Fuchs' spot at the macula forms due to the proliferation of pigment epithelium and deposition of blood pigment following choroidal haemorrhage from the neovascular tissue.[15] The Forster-Fuchs' spot has been found in 3.2% to 20% of patients identified with pathologic myopia.[16]

Lacquer cracks or ruptures in the retinal pigment epithelium-Bruch's membrane-choriocapillaris complex have been reported in patients with high myopia.[17] The prevalence of lacquer cracks has ranged from 0.2% to 9.2% in highly myopic populations. Up to 6.3% of highly myopic eyes have been reported to develop asymptomatic macular holes and foveal retinoschisis.[18,19]

Peripheral retinal features of myopic retinopathy include lattice, paving stone, white-without-pressure, and pigmentary degenerations, as well as retinal tears. In our study the lesions such as lattice degeneration (7.5%) and retinal break (7.5%) was found in only high myopic group ($p < 0.05$). Lattice degeneration presents about 10% and retinal break 6.3% in high myopia.[19] Retinal detachment was found in 0.015% of patients with less than 4.75 D, 0.07% of patients with < -5 D, and 3.2% of patients with < - 6D, and may characterize an unfavorable prognosis in patients with pathologic myopia.[20,21] Peripapillary atrophy was the most common finding associated with the myopic fundus in our study, observed in 40 subjects (100%). It was found that longer axial length was associated with increased prevalence of lattice degeneration, paving stone degeneration, and white-without-pressure.[18,19] White-without-pressure, pigmentary and paving stone degenerations were not found in our study, possibly because of the small number of cases in this study.

Optic disc tilting was thought to be more common in those with astigmatism or high refractive error, particularly myopia.27 Disc tilt was observed in 4 subjects (10.0%) in high myopic group ($p < 0.001$). Prevalence of glaucoma and ocular hypertension was higher in high myopic group in our study.

Primary open angle glaucoma (7.5%), ocular hypertension (5%), and steroid induced glaucoma (5%) were observed in high myopic group ($p < 0.05$). An association between high myopia and primary open angle glaucoma has been supported by numerous case series, case control and large population based studies. The prevalence of myopia with primary open angle glaucoma is 4% and may increase to 6-7% with higher degrees of myopia.[22] Both the Blue Mountains Eye Study (BMES) and Barbados Eye Study (BES) confirm a dose-response between the level of myopia and prevalence of glaucoma (High myopia-4.4%, Emmetropia-1.5%, Hyperopia-2.8%).[23] Additionally, there is now evidence that myopia is a risk factor for the development of ocular hypertension, based on data of the screening examination for the Early Manifest Glaucoma Trial and other studies.[24]

Prevalence of cataract is not statistically different between mild, moderate and high myopic groups in our study. However, a relationship between myopia and posterior subcapsular cataract was found in our study. Prevalence of subcapsular cataract was 2.5% in moderate to high myopic group but 12.5% in high myopic group. High myopia is complicated by the frequent and early development of cataracts. An association with high myopia and the incidence of cataract studies, based on cross- sectional data from the BMES revealed a strong association between high myopia and nuclear cataracts and PSC, and the Beaver Dam Eye Study showed that high myopia was also a risk factor for cataract formation.[25] In BMES, incident PSC was associated with the presence of myopia (OR 2.1, 95% CI 1.0-4.8), moderate to high myopia (-3.5 D or less, OR 4.4, 95% CI 1.7-11.5).[26] Several population and clinic based studies have confirmed a strong and consistent association between high myopia and age related nuclear sclerosis in adults aged more than 40 years.[27] But there was no strong correlation in our study.

Myopic strabismus fixus is a rare strabismus disorder. This disease may progress over several years, from a small degree of esotropia with free ocular movement to the end stage of large angle fixed esotropia. In our study, 2 esotropia cases were found in high myopic group ($p < 0.05$). The underlying etiology remains uncertain yet. Yokoyama et al provided the most recent explanation that it might be caused by the enlarged globe in high myopia which herniated superotemporally and retroequatorially through the muscle cone.[11]

Given the alarming rates of myopia in Asia, there will be an enormous adult population at high risk of developing pathologic myopia. We documented the 2 most common fundus findings, staphyloma and chorioretinal atrophy, in myopic adults. In general, sex did not alter the prevalence of pathologic myopia findings; however, several differences with respect to age group were seen. Staphyloma or chorioretinal atrophy was absent in younger Thai subjects (age < 40) with high myopia. The clinical implications of the ethnicity differences are unclear, and the only visually blinding complication of pathologic myopia found to be of borderline significance is staphyloma among different nations (Malaysia 32.69%; Australia 52.2%; Japan 90%).[28] Finally, the increasing prevalence of staphyloma and chorioretinal atrophy with more severe refractive error in our study emphasizes that preventive strategies to slow the progression of myopia in childhood to prevent the eventual development of extreme myopia in adulthood are important.

There are some limitations in this retrospective study. Participants who responded could be different from those who did not, leading to selection bias and underestimation of true prevalence. Future

prospective, longitudinal studies using fluorescein angiography and spectral-domain OCT technologies may better delineate the evolution of pathologic myopia. Clinically, ophthalmologists should be aware that the pattern of pathologic myopia may differ across ages and severity of refractive errors. High-risk adults who are older with more severe myopia could be identified for regular screening and early management.

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Abbreviation

AL - Axial length

BES - Barbados Eye Study

BMES- Blue Mountains Eye Study

D - Diopters

FFA - Fundus fluorescence angiography

HFA- Humphrey Field Analyzer

OCT - Optical coherence tomography

POAG - Primary open angle glaucoma

SE - Spherical equivalent

WHO - World Health Organization