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Ocular pathology of hyperopic patients in University Eye Clinic

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Abstract

Hyperopia can be associated with a variety of ocular pathology as strabismus, amblyopia, primary angle-closure glaucoma, abnormal binocularity, uveal effusion, pseudo papilledema, and non-arteritic anterior ischaemic optic neuritis. No previous study of ocular pathology in hyperopia was published in Thailand. This research aims to gather baseline data and determine the correlation between the degree of hyperopia and the presence of ocular pathology seen using a retrospective study of medical records of patients at the university's eye clinic from January 2015 to December 2017. A total of 4,354 patients were observed with a ratio between men and women of 1,998:2,356 and ages ranging from 1-102 years with a mean age of 49.9 ± 20.14 in men and 53.32 ± 18.93 in women. Of 1,264 hyperopic patients observed, 835 had a spherical equivalent (SE) of +2 Diopters or less (mild hyperopic), 391 had a SE of greater than +2 D but not greater than +5 D (moderate hyperopia), and 38 patients had a SE of greater than +5 D (high hyperopia). Glaucoma and related diseases were the most common ocular pathology (15.75%), followed by posterior vitreous detachment (10.8%). Ocular conditions such as strabismus (1.75%) and amblyopia (1.32%) were also observed. The correlation study showed that primary open-angle glaucoma, primary angle-closure glaucoma, primary angle-closure strabismus, and amblyopia were related to hyperopia as more hyperopic had a higher correlation. In conclusion, hyperopia had many associations with many ocular pathology and conditions in children and adults, and the optometrist should do primary eye care screening during refraction, especially in the elders.

Keywords*: amblyopia, angle-closure, glaucoma, hyperopia, ocular pathology, strabismus*

1. Introduction

Hyperopia is the most common refractive error in children which can be found with a power of between +2.00 Diopters (D) and +3.50 D. The prevalence 4-9% at the ages of 6-9 months and decreases to 3.6% at the age of one year from emmetropization (Somer, Karabulut, Cinar, Altiparmak, & Unlu, 2014). At the age of 4, a power of between +2.25 to + 5.00 D is found, of which 12% is ≥ +3.00 D (Wen et al., 2013). Between the ages of 4.5 - 7, the mean refractive error is +1.75 D (Sandfeld, Welhrauch, Tubaek, & Mortzos, 2018). After the ages of 10-15, hyperopia will become myopia. If there is no eyeglasses correction, the children will have 13 times more strabismus and 6 times less visual acuity when compared to the children without hyperopia (Babinsky & Candy, 2011). Based on the population-based study in Thailand in 2007, the prevalence of hyperopia in all age groups was 3.44% by Epidemiological definition (≥+3,00 D) and 26.30% by Australian definition (≥+1.00 D) (Jenchitr & Raiyawa, 2011).

The association between hyperopia and the presence of ocular conditions such as strabismus, amblyopia has been proved for young children (Bruce & Santorelli, 2016), with reduced visual functions (distance Visual Acuity – VA), binocularity, near VA, reduced stereo acuity, and differences in convergence-to-accommodation (AC/A) ratio (Candy, Gray, Hohenbary, & Lyon, 2012; Fu et al., 2014). In adults, many ocular pathology were listed such as uveal effusion (Butler, 2004), pseudo-papilledema (Gutteridge, 1981), non-arteritic anterior ischemic optic neuropathy; AION ((Pahor and Gracner, 2008), AION (Katz & Spencer, 1993), angle-closure glaucoma (Pitts & Jay, 1990; Sonmez & Ozcan, 2012; Zhang, Wang, Aung, Jonas, & Wang, 2015), and retinal vein occlusion (Albar, Nowilaty, & Ghazi, 2015). Also, hyperopic patients are shown to have a risk of glaucoma as compared to non-hyperopic patients (Wong, Klein, Klein, Knudtson, & Lee, 2001). Today, prophylactic laser iridotomy was an acceptable procedure and has been frequently performed to prevent acute angle-

closure glaucoma (Grodum, Heijl, & Bengtsson, 2001).

2. Objectives

This study aims to gather baseline data and determine if there was any correlation between the degree of hyperopia and the presence of ocular pathology as patient outcomes and research.

3. Materials and methods

A retrospective descriptive study of hyperopic patients at the University's Eye Clinic between January 2015-December 2017 was performed. The study inclusion criteria were that the patient had completed an eye examination, which included a measurement of visual acuity, a measurement of intraocular pressure by non-contact tonometer. If the intraocular pressure were high, the eye examination would be repeated by an applanation tonometer, auto and manifest refraction, external ophthalmic examination, gonioscopy, fundus examination, and fundus photography. Additional testings such as fundus fluorescein angiography, ultrasonography, optical coherence tomography, and automated perimetry were also performed when indicated as in the case of hyperopic chorioretinal abnormality, glaucoma (disc) suspected, and others. A definite diagnosis was made by glaucoma and retina specialist and pediatric ophthalmologist. Patients with missing or incomplete exam data were excluded from the study. Ocular pathology was tabulated and categorically analyzed by a degree of hyperopia (mild hyperopia is +2 diopters or less), moderate hyperopia (>+2 to +5 diopters), or high hyperopia (more than +5 diopters).

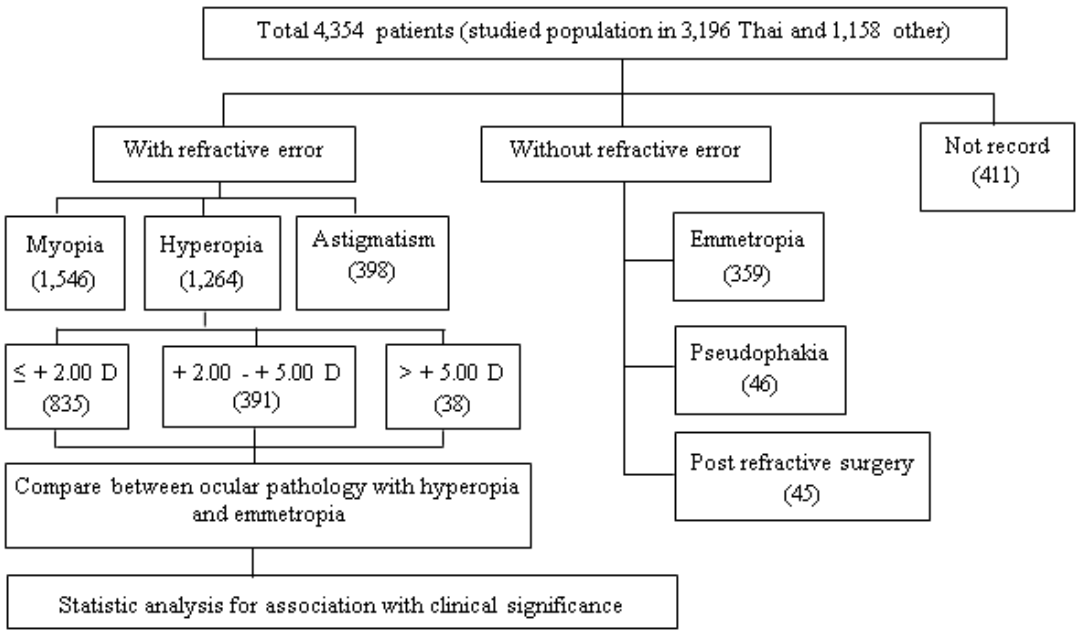

Figure 1 Conceptual framework of hyperopic research

4. Results

A total of 4,354 patients (Figure 1) were observed, including 1,998 men and 2,356 women. Ages of the patients were ranging from 1-102 years with a mean age of 49.90 ± 20.14 in men and 53.32 ±18.93 in women, as shown in Table 1. Four hundred and eleven (411) patients were not refracted and excluded from the calculations to correlate pathology with hyperopia, and 359 had no refractive error (a group of pseudophakia and post-refractive surgery were also excluded). One thousand five hundred and forty-six (1,546) patients were myopia (39.21%) while 1,264 were hyperopia (32.01%) with the following breakdowns; 835 (66.%) were mild hyperopia (SE +2 diopters or less), 391 (31%) were moderate hyperopia (SE greater than +2.25 but less than +5 diopters), and 38 (3%) were high hyperopia (SE greater than 5 diopters), as shown in Table 2.

The ocular pathology of hyperopia and conditions found in the studied group were listed in Table 3, ordering from the most to the least common. Glaucoma and related group were the most common (621 cases), second common was posterior vitreous detachment (426 cases), primary open-angle glaucoma (135 cases), primary open-angle glaucoma suspected (126 cases), primary angle-closure (113 cases), normotension glaucoma (92 cases), ocular hypertension (72 cases). A total of 33 patients had laser peripheral iridotomy, and 10 had a history of glaucoma surgery as shown in Table 3.

For ocular conditions, strabismus (61 cases), amblyopia (52 cases), computer vision syndrome (45 cases), and central serous chorioretinopathy (30 cases) were found. They were common in children and young adults but found less in this study. Ocular diseases in the different age groups were shown in Table 4. Strabismus was common in ≤ 20 years old age group while PVD and glaucoma group had a high prevalence in 51-70 years age group. With Pearson's Chi-square test (Table 5), high hyperopia had a risk of strabismus when compared to emmetropia (OR=6.07, 95%CI 1.39-26.47), moderate hyperopia had a risk of amblyopia when compared to emmetropia (OR=11.34, 95%CI 1.47-87.62.), and high hyperopia had a risk of amblyopia when compared to emmetropia (OR=208.83, 95%CI 26.34-1635.77).

For glaucoma, mild hyperopia had a risk of primary open-angle glaucoma (POAG) when compared to emmetropia (OR=2.50, 95%CI 1.04-6.00), moderate hyperopia had a risk of POAG (OR=4.89, 95%CI 2.01-11.89), and high hyperopia had a risk of POAG when compared to emmetropia (OR=21.01, 95%CI 7.12-62.05). Primary angle-closure glaucoma (PACG) were correlated with mild and moderate hyperopia when compared to emmetropia (OR=6.99, 95%CI 0.92-52.94, OR11.34,95%CI 1.46-87.62). PAC was correlated with moderate hyperopia when compared to emmetropia (OR=2.25,95%CI 1.21-4.20). Glaucoma suspected had conversely correlated with mild and moderate hyperopia (OR=0.45, 95%CI 0.29-0.70, OR=0.37,95%CI 0.21-0.66), as shown in Table 5.

In this study, posterior vitreous detachment, normotension glaucoma, ocular hypertension, laser peripheral iridotomy, central serous chorioretinopathy, and computer vision syndrome were not associated with any hyperopia.

5. Discussion

The presence and magnitude of hyperopia among preschool children were associated with higher proportions of amblyopia, strabismus. While, anisometropia and poor stereo acuity were associated too even among non-strabismic, non-amblyopic children (Giordano et al., 2009; Kulp et al., 2016). In this study, minimal strabismus and amblyopia were found in the studied population with the mean age of 51.77 ± 19.56 years. In primary school children, refractive error was the most common type of ocular morbidity (2.36%). Hyperopia (0.84%) was more common than myopia (0.64%) (Sherpa, Panta, & Joshi, 2011). For adults, according to Singapore and Malay Eye Study, with the mean age of 58 ± 11 years, 35.3% of the studied group had hyperopia, 4.6% were diagnosed with glaucoma, and 0.2% had angle-closure glaucoma (Rosman et al., 2012), which was similar to this study regarding the number of hyperopias (32.05%). However, the difference in glaucoma prevalence (POAG, PACG, and NTG) was 8.01% since this study was done in the university's eye clinic, not a population-based.

Due to the mean age of this studied population, which was 51.77 ± 19.56 years, the main causes of visual impairment were refractive error and cataract, which was the same as Taiwanese (Wang et al., 2016) and Indian population (Senjam et al., 2016). There was a hyperopic shift with the mean 5-year change in the spherical equivalent refraction of +0.24 to +0.5 D in the 40-to-64-year-old population, and at 65 years, they will develop at least –0.5 D myopic shifts due to nuclear cataract. Therefore, in this study, the refractive error of cataract and post-refractive surgery cases were excluded.

Strabismus individuals had more hyperopia (40%) (Schaal et al., 2018), and increasing strabismus correspond to increasing hyperopia (Bruce & Santorelli, 2016). Children with hyperopia greater than +3.5 D were at increased risk for developing refractive esotropia (Babinsky & Candy, 2011). All of these previous findings were the same as this study since high hyperopia had a risk of strabismus as compared to emmetropia (OR=6.07, 95%CI 1.39-26.47). A study showed an association of hyperopia with concomitant esotropia (Zhu et al., 2015). However, in this study, there were only 5.35% of the $\leq$20-year population, which was inadequate to study concomitant esotropia.

It is known that there is a high prevalence of amblyopia among children with refractive

errors, particularly high hyperopia and anisometropia (Rajavi et al., 2015). In students, amblyopia prevalence was 1%, whereas most amblyopic eye (38.9%) are hyperopic with a spherical equivalent of ≥3D (Fu et al., 2014), and was the main cause of monocular impaired vision in childhood. However, in this study, only 1.32% of amblyopia was found. Instead, moderate and high hyperopia (SE +2.25->+5.00 D) were found more since the study was done in the university's eye clinic, where consultation from another eye professional was received.

For binocular vision, stereopsis, uncorrected hyperopia of ≥4.0 D, or hyperopia of ≥3.0 to ≤6.0 D were associated with reduced binocular near VA (20/40 or worse) or reduced near stereo acuity (240 seconds of arc or worse) in preschool children (Kulp et al., 2014). In this study, due to the study in adults and senile cases, binocular vision and stereopsis were not routinely recorded. Consequently, no correlation analysis was performed.

For glaucoma, the definition of primary angle-closure is irido-trabecular apposition of >180 degrees (Barkana et al., 2012). For Primary angle-closure diseases, the prevalence in Asian countries generally associates with a shallow anterior chamber, hyperopia, female, shorter axial length, and thick lens. Hyperopia associated with a substantially increased prevalence of PACG. Each 1 D reduction in SE was associated with a 22% decrease in the odds of PACG (Shen et al., 2016). Poor detection rates were probably due to a lack of gonioscopy as a routine part of eye examination of the hyperopic case. Hyperopic patients with narrow angles are at risk for angle-closure and should be carefully monitored (Paciuc, Valasco, & Naranjo, 2000).

For ocular hypertension, in a white population, after controlling for age, gender, and baseline IOP, persons with hyperopia were 40% more likely to have an incident of ocular hypertension than those who were emmetropia at baseline (Wong et al., 2001). In this study, only 2.16 % of ocular hypertension was found, and there was no correlation with hyperopia.

For uveal effusion syndrome, it was reported following the laser in situ keratomileuses (LASIK) for hyperopia (Butler et al., 2004), but it was not found in this study.

For non-arteritis anterior ischemic optic neuropathy (NAION), which is more common in over 50 year age group, but there were reported in young hyperopic patients, from +0.50 to +2.00D. There was a report that the mean refractive error (in spherical equivalents) for the NAION group was +0.26 diopter +/- 2.08 (Katz & Spencer, 1993). The majority of NAION were hyperopia (71,1%). The average degree of hyperopia was +1.86 D (Pahor & Pahor, 2016). In this study, only 2 cases had NAION, a 41-year-old man with mild myopia and a 50-year-old man with mild hyperopia; therefore, it was an inadequate case for correlation study.

6. Conclusion

Hyperopia is the most common refractive error in children. After the ages of 10-15, hyperopia will change to myopia. As in this study, hyperopic children had strabismus and amblyopia. So, the optometrist should participate in the Thai government program of school eye health. In the adults and aging population, glaucoma was correlated with hyperopia. As optometrists routinely observe hyperopic and presbyopic cases, they should be aware of glaucoma prevalence, which is a risk of permanent visual impairment and should be carefully monitored.

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Table 1 Demography of studied population

Age range (years)	Sex		Total	Nationality		Total
	Male	Female		Thai	Other	
1 - 10	42	29	71	30	41	71
11 - 20	109	53	162	114	48	162
21 - 30	299	264	563	453	110	563
31 - 40	231	298	529	385	144	529
41 - 50	261	311	572	365	207	572
51 - 60	333	436	769	518	251	769
61 - 70	402	496	898	676	222	898
More than 70	321	469	790	655	135	790
Total	1,998	2,356	4,354	3,196	1,158	4,354

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Table 2 Type of refractive error of studied population

Age range (years)	Refractive error						No refractive error				Not record****
	M1	M2	M3	H1	H2	H3	Astig matism*	Pseudo Phakia*	Post refractive surgery***	Emme tropia	
1-10	11	8	4	13	2	1	11	0	0	9	8
11 - 20	39	26	12	7	4	1	10	0	0	14	45
21 - 30	172	78	40	21	7	4	32	1	32	74	1
31 - 40	184	63	46	26	3	4	33	1	8	73	70
41 - 50	127	56	37	115	22	7	45	1	3	84	0
51 - 60	115	61	51	237	74	9	62	7	1	48	86
61 - 70	134	75	33	236	149	4	92	15	0	31	96
More than 70	135	26	13	180	130	8	113	21	1	26	105
Total	917	393	236	835	391	38	398	46	45	359	411

*Astigmatism could be found as congenital, developmental, pseudophakia or post-refractive surgery
**Some pseudophakia could be emmetrope before cataract operation but were excluded in this study
***Some case of post refractive surgery may have refractive error or astigmatism
****No record means some cataract cases can cause myopic shift or some cases came for special investigation only eg. endothelial cell count, contrast sensitivity function etc

Table 3 Ocular diseases and refractive error*

Ocular diseases	M1	M2	M3	H1	H2	H3	Astig matism	Total	% of RE
PVD	101	67	58	110	53	1	36	426	13.28
POAG	34	12	14	34	30	10	1	135	4.21
POAGS	27	20	4	40	15	1	19	126	3.93
PAC	13	6	2	42	35	2	13	113	3.52
NTG	25	7	3	31	18	0	8	92	2.87
OHT	28	15	3	16	6	1	3	72	2.24
Strabismus	14	7	5	18	6	3	8	61	1.90
Amblyopia	2	5	6	10	12	14	3	52	1.62
CVS	17	7	0	16	4	1	-	45	1.40
PACG	6	4	2	16	12	0	0	40	1.25
CSC	8	2	5	13	6	0	-	34	1.06
LPI	6	3	1	10	9	1	3	33	1.03
Glaucoma surgery	3	1	0	3	2	0	1	10	0.31

* For Table 3
M1 - 0.50-3.00 D M2 -3.25-6.00 D M3 >-6.00 D H1 +0.50-+2.00 D H2 +2.25-+5.00 D
H3 >+5. 00 D Astigmatism ±1.00 D PVD- Posterior vitreous detachment
POAG- Primary open angle glaucoma POAGS - Primary open angle glaucoma suspected
PAC - Primary angle closure PACG - Primary angle closure glaucoma
NTG - Normotension glaucoma
LPI- Laser peripheral iridotomy OHT - Ocular hypertension
CVS- Computor vision syndrome CSC - Central serous chorioretinopathy

Table 4 Ocular diseases in different age group*

Ocular diseases	Age range (years)							Total	% of pop. sample
	≤20	21-30	31-40	41-50	51-60	61-70	> 70		
PVD	-	20	40	55	144	128	39	426	9.78
POAG	-	3	5	15	23	38	51	135	3.10
POAGS	-	10	18	21	29	34	14	126	2.89
PAC	-	1	2	18	27	42	23	113	2.60
NTG	-	1	3	4	16	29	39	92	2.11
OHT	-	8	5	17	19	18	5	72	1.65
Strabismus	25	11	8	5	5	4	3	61	1.40
Amblyopia	10	11	3	10	11	5	2	52	1.19

CVS	10	13	11	8	1	2	-	45	1.03
PACG	-	0	0	3	7	14	16	40	0.92
CSC	-	6	10	8	8	2	-	34	0.78
LPI	-	-	2	5	10	12	4	33	0.76
Glaucoma surgery	-	-	1	3	2	2	2	10	0.23

* For Table 4
M1 - 0.50-3.00 D M2 -3.25-6.00 D M3 >-6.00 D H1 +0.50-+2.00 D H2 +2.25-+5.00 D
H3 >+5. 00 D Astigmatism ±1.00 D PVD- Posterior vitreous detachment
POAG- Primary open angle glaucoma POAGS - Primary open angle glaucoma suspected
PAC - Primary angle closure PACG - Primary angle closure glaucoma
NTG - Normotension glaucoma
LPI- Laser peripheral iridotomy OHT - Ocular hypertension
CVS- Computor vision syndrome CSC - Central serous chorioretinopathy

Table 5 Ocular pathology and correlation with hyperopia

Ocular pathology	Hyperopia	Odds ratio	95%CI	P-value	Significance
Strabismus	High hyperopia	6.07	1.39-26.47	0.030 [b]	Sig
Amblyopia	Moderate hyperopia	11.34	1.47-87.62	0.003 [a]	Sig
	High hyperopia	208.83	26.34-1655.77	0.000 [b]	Sig
Primary open	Mild hyperopia	2.50	1.04-6.00	0.034 [a]	Sig
angle glaucoma	Moderate hyperopa	4.89	2.01-11.89	0.000 [a]	Sig
	High hyperopia	21.01	7.12-62.05	0.000 [b]	Sig
Primary angle	Mild hyperopia	6.99	0.92-52.94	0.028 [a]	Sig
closure glaucoma	Moderate hyperopia	11.34	1.46-87.62	0.003 [a]	Sig
Glaucoma	Mild hyperopia	0.45	0.29-0.70	0.000 [a]	Sig
suspected	Moderate hyperopia	0.37	0.21-0.66	0.000 [a]	Sig
Primary angle	Moderate hyperopia	2.25	1.21-4.20	0.008 [a]	Sig
closure					

An odds ratio of more than 1 means that hyperopia had a high risk for ocular pathology
An odds ratio of less than 1 means that hyperopia had a low risk for ocular pathology or less correlation
[a] Based on Chi-square test, p<0.05 was considered statistically significant
[b] Based on Fisher's exact test, p<0.05 was considered statistically significant

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