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Refractive Error of the Elderly Presenting to a University Eye Clinic

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Abstract

The prevalence of refractive errors varies by age and gender and is closely related to functional difficulties, ocular diseases, and decreased quality of life. The purpose of this study was to assess associations of age and gender with refractive errors of the elderly presenting at a university clinic. Retrospective review of medical records of elderly patients presenting for eye services in 2020-2021. Demographic, ocular disease and refractive data were collected and analyzed. The number of 1,452 patients aged 60 and over with a mean age of 69.6 ± 8.09 years (range 60 to 101 years) were included. The prevalence of myopia, hyperopia, astigmatism, and anisometropia was 22.4%, 36.5%, 22.7%, and 19.4%, respectively. Compared to those aged 80 and above, myopia increased 5.171 times in those 60-69 yrs and 4.930 times among those 70-79 yrs. Men were significantly more likely to have myopia than women ($p<0.001$). Hyperopia was significantly less prevalent in those aged 70-79 and aged 80 and above compared to those aged 60-69 ($p<0.001$). Gender was not associated with hyperopia ($p=0.066$). The prevalence of astigmatism and anisometropia was higher in older subjects. Astigmatism shifted from with-the-rule (WTR) to against-the-rule (ATR) with age. Astigmatism had no gender difference, but anisometropia was more common in women. Most anisometropia was due to refractive error. Rates of myopia and hyperopia decreased with age while astigmatism increased with age. Thai optometrists need to be aware that refractive error in the elderly is not stationary and frequent changes in spectacle power may be needed.

Keywords**:** *refractive errors; anisometropia; elderly; university eye clinic; myopic macular degeneration*

1. Introduction

Refractive error is one of the most common causes of vision loss in the elderly with an estimated 158 million cases of distance vision impairment (VI) and 544 million cases of near vision impairment caused by uncorrected refractive error (URE) worldwide in 2007 (Fricke et al., 2012). Uncorrected refractive error (URE) adversely affects the quality of life and ability to perform basic activities in the elderly, is associated with falls, social isolation, depression, and worsening dementia, and may be a sign of self-neglect of health. Uncorrected refractive error is estimated to cost the economy of Britain £15.8 billion (Pezzullo et al., 2018) and has been estimated to cost the global economy $244 billion US per year. Globally, economic loss from uncorrected myopia alone is estimated at $49 billion per year (Naidoo et al., 2019), while in Americans ≥ 50 years old, the productivity lost annually is estimated to be $121.4 billion US (Smith et al., 2009). All these problems can be easily solved by refraction and appropriate affordable eyeglasses correction.

The prevalence of refractive error and URE reported in research is not always comparable between studies due to differences in methodology,

study definitions and age ranges used. Population-based findings cannot be compared to clinical findings. Elsewhere, URE rates vary from 10.2% in India (Sheeladevi et al., 2019) to 21.2% in the United Kingdom (Sherwin et al., 2012). The rate of URE in Thailand is 23.54% (Jenchitr, & Raiyawa, 2012).

Globally, URE is the leading cause of vision loss among those with moderate and severe visual impairment (MSVI) in the age groups 50–59 and 60–69 years, while cataracts are the principal cause of MSVI in those aged 70 years and older (Steinmetz, 2021; Jenchitr et al., 2024). The World Health Organization (WHO) is now prioritizing the importance of national effective refractive error coverage. Thailand's elderly population is rapidly increasing and Thailand lacks data on the prevalence of refractive error in the elderly.

2. Objectives

The aim of this study is to determine the rate of refractive error among the elderly presenting at Rangsit University eye clinic and to assess associations between refractive error and age, gender and eye diseases.

3. Methods

The study complied with the Helsinki Declaration's guidelines and was approved by the Human Research Ethics Committee at Rangsit University (RSU-ERB 2022 160 0709, approval October 31,2022). We retrospectively reviewed clinical records of all patients aged 60 and above attending the eye clinic of Rangsit University (RSU Healthcare) from January 1, 2020, to December 31, 2021. Most of those attending this clinic come from middle or upper-income families.

All those under age 60 were excluded. Additional exclusions included those recorded as having corneal transplantation, ocular disease, or media opacity that precluded the ability to do a refraction. Refractions were done in two steps: objective refraction by auto refractometer followed by retinoscopy and subjective manifest refraction conducted by a qualified optometrist. All visual acuity data, eye examination data and refraction data were entered into a study database, with no patient identification data included to maintain the anonymous status of all patients. Myopia was defined as having a spherical equivalent (SE) refraction of -0.50 diopters (D) or less, while hyperopia was defined as having an SE refraction of +0.50 D or more. Astigmatism was defined as cylinder power of 1.00 D or more, and anisometropia was defined as at least a 1.00 D difference in SE between the two eyes.

3.1 Statistical analysis

Means and standard deviations were calculated for continuous variables and percentage were determined for categorical variables. The associations of each type of refractive errors (myopia, hyperopia, astigmatism) with age and gender were explored using univariate regression analysis, and further explored in multivariable logistic regression models. Statistical analysis was conducted with SPSS program version 29 and a p-value less than 0.05 was considered significant.

4. Results

Out of a total of 22,563 patients attending RSU Healthcare in 2020 and 2021, a total of 1,898 or 8.4% were aged 60 and above were included in the study. The mean age of the study subjects was 69.6 ± 8.09 (range 60-101) years, and 53.4% were female. Table 1 provides a general description of age and gender distribution of the study participants.

Table 1 Description of elderly patients attending RSU eye clinic, 2020-2021

Age (year)	Number of elderly patients			Number of elderly with refraction			Number of elderly with refractive errors			Number of elderly without refractive error after ocular surgery			Number of elderly with complete eye examination		
	Male	Female	Total	Male	Fem	Total	Male	Fem	Total	Male	Fem	Total	Male	Fem	Total
60-69	554	607	1,161	356	380	736	277	318	595	62	20	82	422	465	887
70-79	217	296	513	148	219	367	127	189	316	16	22	38	166	230	396
80 up	114	110	224	69	95	164	38	84	122	22	2	24	69	100	169
Total	885	1,013	1,898	573	694	1,267	442	591	1,033	100	44	144	657	795	1,452

Of the 1,267 study subjects with complete refraction data, 1,033 had refractive errors (81.5%), 234 (18.5) subjects were emmetropic, of which 144 received ocular surgery, 63 pseudophakia and 81 post-refractive surgery (Table 1). For visual acuity at distance, 284 had myopia (22.4%), 462 had hyperopia (36.5%), 287 had astigmatism (22.6%), 234 had emmetropia (18.5%) (Table 2), and 246 had anisometropia (19.4%) (Table 4). Presbyopia was not included in this study. Among those attending who wore eyeglasses, 16.5% were found to have an improper power of eyeglasses.

4.1 Myopia

As seen in Table 2, myopia (any level) was associated with younger age ($p< 0.001$). Low myopia (-0.50 to -3.00) was significantly associated with younger age ($p<0.001$) but this association was not significantly present in moderate or high myopia. Myopia (any level) was also associated with being male ($p=0.021$); however, when looking at the severity of myopia, the relationship with the male gender was only significant at the low myopia level ($p = 0.025$). According to Table 3, among the 712 cataract patients, 14.5% had mild myopia, 5.2% had moderate myopia, and 1.7% had high myopia. Myopia was found in 17.3% of the 301 pseudophakic patients (Table 3).

4.2 Hyperopia

As seen in Table 2, hyperopia (any level) was associated with younger age ($p<0.001$). Mild hyperopia was associated with younger age ($p=0.005$) but not moderate hyperopia ($p=0.087$). There were not enough cases to assess this relationship in high hyperopia. Hyperopia (any level) and mild hyperopia were not associated with gender, but moderate hyperopia was significantly associated with being female ($p=0.002$). Mild and moderate hyperopia were found in those with cataracts in 28.2% and 11.1 %, respectively (Table 3). For pseudophakic patients, mild and moderate hyperopia were found at 9.6% and 2%, respectively (Table 2).

4.3 Astigmatism

Astigmatism of any orientation was associated with increasing age ($p<0.001$) and ATR astigmatism was also associated with increasing age ($p<0.001$) but no association was found with WTR astigmatism ($p=0.075$). There were not enough cases to assess age or gender associations with oblique and irregular astigmatism and no association was found between gender and astigmatism in any orientation (Table 2). Among cataract patients, 21.1% were found to have astigmatism, and 18% were found to have ATR astigmatism. Astigmatism was found in 25.9% of pseudophakic patients and ATR astigmatism was found in 19% of pseudophakic patients (Table 2).

4.4 Cataract

As seen in Table 3,712 people presenting with cataracts showed no association with gender in any refractive category except myopia, which was associated with being female ($p=0.025$). Cataract with astigmatism was associated with older age ($p<0.001$). No age association of cataract was found with myopia and hyperopia. For patients with cataracts, myopia, hyperopia, and astigmatism were found at 21.3%, 39.3%, and 21.1% respectively (Table 3).

4.5 Pseudophakia

As seen in Table 3, among those with 301 pseudophakia, no associations were found with type of refractive error and gender except for hyperopia, which was associated with being female ($p=0.002$). Increasing age was associated with astigmatism ($p<0.001$) while younger age was associated with myopia ($p<0.001$). No age association was found for pseudophakia and hyperopia. In a sub-group analysis of astigmatic type, lower astigmatic power of 1-2 D was more common than higher powers in both cataract and pseudophakic participants ($p<0.001$). For astigmatic orientation, ATR astigmatism was more common than WTR astigmatism in both cataracts and pseudophakia ($p<0.001$). For pseudophakic patients, the prevalence of myopia, hyperopia, and astigmatism was 17.3%, 11.6%, and 25.9%, respectively.

4.6 Other eye diseases

From Table 3, glaucoma, diabetic retinopathy, and age-related macular degeneration had refractive error rates of 8.5%, 5.2%, and 4.7%, respectively. Other eye diseases included pterygium, corneal scar, keratoconus, post-refractive surgery, post-op pars plana vitrectomy, post-retinal photocoagulation, retinitis pigmentosa, and chorioretinal scar when combined had a 9.2% rate of refractive error.

Table 2 Refractive Error by type and severity by age and gender among elderly attendees

Grading and type of refractive errors		Number (Percent)						Total refraction (Percent)	p-value (For age group)	p-value (For Gender)
		60-69 years		70-79 years		80 years and over				
		Male	Female	Male	Female	Male	Female			
Myopia*	Low (-0.50 to – 3.00 D)	67(18.8)	64(16.8)	30(20.2)	36(16.4)	7(10.1)	1(1.1)	205(19.8)	**p<0.001**	**p=0.025**
	Moderate (-3.25 to -5.00 D)	16(4.5)	19(5.0)	6(4.1)	10(4.6)	1(1.4)	- 1(1.1)	52(5.0)	p=0.051	p =0.931
	High (Less than -5.00 D)	9(2.5)	10(2.6)	5(3.4)	2(0.9)	-		27(2.6)	p=0.269	p =0.385
Total Myopia									**p<0.001**	**p=0.021**
Hyperopia**	Low (+0.50 to +2.00 D)	104(29.2)	119(31.3)	32(21.6)	50(22.8)	12(17.4)	23(24.2)	340(32.9)	**p=0.005**	p=0.959
	Moderate (+2.25 to +5.00 D)	24(6.7)	53(13.9)	10(6.7)	26(11.9)	3(4.3)	5(5.3)	121(11.7)	p=0.087	**p=0.002**
	High (More than +5.00 D)	-	-	-	-	1(1.4)	-	1(1)	NTR	NTR
Total Hyperopia									**p<0.001**	p =0.66
Astigmatism ***	With the rule	11(3.1)	5(1.3)	6(4.1)	11(5.0)	1(1.4)	5(5.3)	39(3.8)	p=0.075	p=0.748
	Against the rule	45(12.6)	47(12.4)	35(23.6)	51(23.3)	12(17.4)	45(47.3)	235(10.3)	**p<0.001**	p =0.123
	Oblique	1(0.3)	-	2(1.3)	3(1.4)	-	2(2.1)	8(0.8)	NIR	NIR
	Irregular	-	1(0.3)	1(0.7)	-	1(1.4)	2(2.1)	5(0.5)	NTR	NIR
Total Astigmatism									**p<0.001**	p=0.165
Total participants with refractive errors		277(26.8)	318(30.8)	127(12.3)	189(18.3)	38(3.7)	84(8.1)	1,033		
Pseudophakic cases without refractive errors		22	30	3	4	1	3	63		
Post refractive surgery without refractive errors		26	27	14	10	1	3	81		
Total participants without refractive error by presenting visual acuity		40	28	11	6	3	2	90		
Total emmetropia (No refractive errors)		28	25	17	39	18	41	234		
Total sample with refraction		356	380	148	219	69	95	1,267		

*Myopia was defined as spherical equivalents -0.50 diopter or less

**Hyperopia was defined as spherical equivalent +0.50 diopter or more

***Astigmatism was defined as a cylindrical error more than 1.00 diopter

NTR– Note to reader - Too small sample size to calculate for p-value for age group and gender difference

Table 3 Refractive error in eye diseases

Grading and type of refractive errors	60-69 years Number		70-79 years Number		≥80 years Number		Number and % of total refraction	p-value for age group	p-value for gender
	Male	Female	Male	Female	Male	Female			
Cataract with Myopia								p=0.485	p=0.025**
-0.50-3.00	35	25	18	17	6	2	103 (9.9)		
-3.25-5.00	8	11	6	10	1	1	37 (3.3)		
≤-5.25	2	5	3	1	0	1	12 (4.2)		
Cataract with Hyperopia								p=0.686	p =0.931
+0.50-2.00	52	63	25	43	6	12	201 (19.5)		
+2.25-5.00	16	31	7	19	1	5	79 (17.1)		
≥+5.25	0	0	0	0	0	0	0		
Cataract with Astigmatism								p<0.001++	p=0.385
WTR	5	1	2	6	0	1	15 (1.5)		
ATR	31	25	21	31	6	14	128 (12.4)		
Oblique	1	0	0	2	0	1	4 (0.4)		
Irregular	0	1	1	0	0	1	3 (0.3)		
Cataract with refractive error							582 (56.3)		
Pseudophakia with myopia								p<0.001+	p=0.959
-0.50-3.00	11	14	4	15	1	1	46 (4.5)		
-3.25-5.00	2	0	0	1	0	0	3 (0.3)		
≤-5.25	2	0	1	0	0	0	3 (0.3)		
Pseudophakia with hyperopia								p=0.303	p=0.002**
+0.50-2.00	4	3	2	7	4	9	29 (2.8)		
+2.25-5.00	1	0	1	3	0	1	6 (0.6)		
≥5.25	0	0	0	0	0	0	0		
Pseudophakia with astigmatism								p<0.001++	NTR
WTR	4	2	4	1	1	3	15 (1.5)		
ATR	4	6	4	11	6	26	57 (5.5)		
Oblique	0	0	1	1	0	1	3 (0.3)		
Irregular	0	1	1	0	0	1	3 (0.3)		
Pseudophakia and refractive error							165 (16.1)		
Glaucoma with RE	17	7	19	20	10	15	88		
Diabetic retinopathy with RE	8	5	12	12	3	14	54		
Age-related macular degeneration with RE	5	9	5	5	8	17	49		
Some major eye diseases (glaucoma, DR, AMD) with refractive error							191 (18.5)		
#Some minor eye diseases with refractive error							95 (9.2)		
Total participants with RE*	277	318	127	189	38	84	1,033		

Cataract and pseudophakia composed of 72.4% of refractive error

Glaucoma, diabetic retinopathy, age-related macular degeneration composed of 18.5% of refractive error

NTR – Note to reader, too small sample size to calculate for p-value for age group and gender difference.

* Percent of total with refractive error data (1,033) including non-cataract and non-pseudophakia, ** associated with being female

+ associated with younger age, ++ associated with older age,

#other eye diseases were pterygium, corneal scar, keratoconus, post-refractive surgery, post-op pars plana vitrectomy, post retinal photocoagulation, retinitis pigmentosa, and chorioretinal scar, all composed of 9.2% of refractive error

Table 4 Number and prevalence of anisometropia by age, gender and type of refractive error

Age group (yrs)	Myopic Anisometropia		Hyperopic Anisometropia		Astigmatic Anisometropia		Total Anisometropia**	
	Number/percent*		Number/percent*		Number/percent*		Number/percent	
	Male	Female	Male	Female	Male	Female	Male	Female
60-69	26(28.3)	37(39.7)	8(6.2)	22(12.7)	15(26.3)	10(18.8)	49(17.6)	69(21.7)
70-79	17(41.4)	21(43.7)	10(23.8)	13(17.1)	13(29.5)	13(20.0)	40(31.5)	47(24.9)
≥ 80	5(62.5)	1(50.0)	3(18.7)	8(25)	5(35.7)	19(35.2)	13(34.2)	28(31.8)
Total	48(34)	59(41.2)	21(11.2)	43(15.3)	33(28.6)	42(24.4)	102(23.1)	144(24.4)

*percent of myopia, hyperopia and astigmatism in each age group

**Anisometropia was defined as the difference in refractive error of both eyes ≥ 1 Diopters

Table 5 Causes of Anisometropia by gender and age

Age group	Male with refractive error (n=442)	Female with refractive error (n=591)	Total causes (n=1,033)
60-69 years 116/595 have anisometropia (19.5%)	Refractive error 14 (High myopia 8, MMD 3, amblyopia 3) Cataract 17 Pseudophakia 11 Pterygium 3 Post refractive surgery 1 Post op PPV 1	Refractive error 40 (High myopia 3, MMD 2) Cataract 14 Pseudophakia 8 Cause not documented 7	Refractive error 54 (High myopia 11, MMD 5, amblyopia 3) Cataract 31 Pseudophakia 19 Pterygium 3 Post refractive surgery 1 Post op PPV 1 Cause not documented 7
70-79 years 87/316have anisometropia (27.5%)	Cataract 18 Refractive error 10 (High myopia 1, amblyopia 1) Pseudophakia 4 Keratoconus 2 Corneal scar 1 Post op PPV 1 Cause not documented 2	Cataract 13 Refractive error 17 (Myopia with amblyopia 1) Pseudophakia 14 (MMD 1) Corneal scar 1 Post PRP with macular hole 1 Cause not documented 3	Cataract 31 Refractive error 27 (Myopia with amblyopia 2) Pseudophakia 18 Keratoconus 2 Corneal scar 2 Post op PPV 1 Post PRP with macular hole 1 Cause not documented 5
≥ 80 years 43/122 have anisometropia (35.2%)	Pseudophakia 6 Refractive error 4 (High myopia 1) Cataract 3	Pseudophakia 15 Refractive error 7 (High myopia with MMD 1) Cataract 6 AMD with high astigmatism 1 Cause not documented 1	Pseudophakia 21 Refractive error 11 (High Myopia 2) Cataract 9 AMD with high astigmatism 1 Cause not documented 1
Total	98 (9.5 %)	136 (13.1 %)	234 (22.6%)

4.7 Anisometropia

Anisometropia was found in 246 people or 23.8% of refractive error cases (Table 4). The most common cause of anisometropia was refractive error with 92 persons (8.9%) of all those with refractive error. From Table 5, among those with anisometropia, 71 persons (6.9%) of the 70-79 age group had cataract. Among those age 80 and up, 58 persons (5.6%) had pseudophakia. Other causes of anisometropia were pterygium, keratoconus, post-refractive surgery, post pars plana vitrectomy, post-pan retinal photocoagulation and age-related macular degeneration. The cause of anisometropia in 15 cases (6.1%) was not documented. From Table 5, anisometropia in the elderly significantly increased from 19.8% in 60-69 age group to 27.5% in 70-79 age group and 35.2% in ≥ 80 age group ($p<0.001$) and women had more anisometropia than men ($p<0.001$) (Tables 4,5).

5. Discussion

We find that hyperopia was the most common type of refractive error among the presenting elderly (Table 2). This is similar to other studies where hyperopia was found to be the most common refractive error in Singapore at 41.5% (Tan et al., 2011) England at 49.4% (Sherwin et al., 2012), rural Japan at 34.1% (Nakamura et al., 2018) Iran at 45.4% (Hashemi, 2023) and previously in Thailand at 36.5% (Jenchitr, & Raiyawa, 2012). But

in many East Asian countries myopia is more prevalent and the world-wide rates of myopia are expected to climb dramatically. Overall, rates of myopia and high myopia are higher in Asians compared to non-Asians (Vitale et al., 2008).

In this study we find that rates of any refractive error and rates of myopia, hyperopia, astigmatism and anisometropia all increase with age, which corresponding to publication from USA that anisometropia develops in all refractive components in the oldest observers. (Haegerstrom-Portnoy et al., 2014) In Thailand, the prevalence of refractive error among the elderly was 60% in a 2007 national population-based survey (Jenchitr et al., 2007) and was found to be to 81.5% in 2021 (Jenchitr, & Jaradaroonchay, 2022) which correlates with the global prevalence (Holden et al., 2016).

Among those attending who wore eyeglasses, 16.5% were found to have an outdated or improper power of eyeglasses. This may be due to changes in refractive error due to age or ocular disease or due to error in refraction or error in fabricating the lenses. Age-related changes in astigmatism are mainly associated with changes in corneal curvature (Namba et al., 2020) as determined by keratometry measurement (Gudmundsdottir et al., 2000). We find a shift with age in orientation from WTR astigmatism to ATR astigmatism, which has also been found in other studies (Asano et al., 2005).

Refractive error due to cataracts occurs most in nuclear sclerosis cataracts (Gupta et al, 2008) as nuclear lens material becomes more denser and changes the refractive index leading to a myopic shift. Cortical cataracts can increase the power of astigmatism. Posterior sub-capsular cataract and nuclear cataract also cause change of axis of astigmatism (Hashemi et al, 2011). After cataract surgery, when the appropriate intraocular lens (IOL) is used, the patients will have no refractive error and will expect good vision without eyeglasses (Lundström et al., 2018). The most common causes of post-operative refractive error in our participants are from inaccurate biometry leading to inaccurate IOL power selection. This can happen in people with previous kerato-refractive surgery, dry eye, or a history of using contact lenses, especially rigid gas-permeable lenses. The final refraction after cataract surgery is normally within 0.5-1.00 D from the intended target (Khoramnia et al., 2022). In our study, 1-2 D myopia was the most common post-operative refractive error (88.4%) likely intended as a monovision correction. Post-operative astigmatism in the 1-2 D range was a common post-operative finding (60.5%) in our study. Fortunately, this range of astigmatic error does not require a toric intraocular lens to correct.

6. Conclusion

We find among a selected urban Bangkok elderly population that a majority will present with refractive errors. We find that with age, the prevalence of myopia and hyperopia decreases, while the prevalence of astigmatism and anisometropia increases, and that astigmatism shifts towards against the rule orientation. With age, those with cataracts or pseudophakia will shift towards less emmetropia and more astigmatism. Our findings are in line with similar studies. In spite of being educated and middle-income or high-income earners, refractive error remains a significant burden among elderly Thai who are residing in Bangkok and using Rangsit University eye services. Thai optometrists need to be aware that refractive error in the elderly is not stationary and that frequent changes in spectacle power may be needed. The national health plan needs to be more receptive to funding refractive correction.

7. Strengths and limitations

Strengths of this study include that it was derived from a large base of clinical records that were systematically reviewed. Refractive error data were categorized according to the most recent international definitions. The major weakness of this study is that it is not from a population-based sample. Therefore, the results from this study would not be generalizable to the Thai population because those presenting for services at this clinic are overwhelmingly urban residing, middle-income or upper-income, and well-educated. However, our study can be used for eye service planning for the specific population Rangsit University eye clinic serves.

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