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Prevalence of Cataract Type in Relation to Axial Length in Subjects with High Myopia and Emmetropia in an Indian Population

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Abstract

Purpose—To compare the prevalence of different types and densities of age-related cataract in subjects with high myopia and emmetropia in the Indian urban clinic-based population.

Design—Prospective observational clinic-based case-control study.

Methods—An observational case-control study of 800 healthy eyes was undertaken at Iladevi Cataract & IOL Research Center, Ahmedabad, India. Subjects with high myopia (axial length [AXL] ≥ 26.0 mm) (n = 400 eyes) and those with emmetropia (AXL 21.0–23.99 mm) were examined (n = 400 eyes). The type of cataract was categorized as: nuclear, cortical, and posterior subcapsular cataract (PSC). Nuclear density was measured based on the Emery and Little classification.

Results—In all the age groups (40+ years old), nuclear cataract was more often encountered in subjects with high myopia (Odds ratio: 3.8, 95% CI 2.9 – 5.2, $P < 0.001$); PSC and mixed cataracts were frequently encountered in subjects with emmetropia ($P < 0.001$). Prevalence of nuclear cataract was higher in subjects with high myopia with increasing AXL when compared with other types of cataract ($P < 0.001$). In all the age groups, the nuclear density was significantly higher than grade 3 in subjects with high myopia when compared to those with emmetropia ($P < 0.001$ in < 70 years of age, $P = 0.003$ in > 70 years of age).

Conclusion—Nuclear cataract was strongly associated with high axial myopia. The density of the cataract was higher in the high myopia group. No association was observed between PSC or cortical cataract and high axial myopia.

INTRODUCTION

High myopia is known to be associated with age-related cataracts.^{1,2} To date, only a few population-based studies^{3,4} have attempted to assess the association between high myopia and age-related cataract. Cross-sectional data from the Blue Mountains Eye Study³ has provided evidence suggestive of an association between high myopia and both nuclear and posterior

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subcapsular (PSC) cataracts. The association between high myopia and nuclear cataract was also supported by data from the Beaver Dam Eye Study.⁴

Myopia can be defined by refractive or axial length (AXL) measurements. In refractive myopia, the overall refractive power of the eye is determined by the cornea, lens, and AXL. Most of the published articles in the literature have defined myopia in terms of refractive error.^{1,2,3,4} Using refractive myopia, it is difficult to differentiate between cause and effect, i.e., whether refractive myopia is a risk factor for cataract or cataract (e.g., nuclear sclerosis) causes refractive myopia. Keeping these limitations in mind, the present study was designed defining myopia in terms of AXL. Eyes with an AXL ≥ 25.0 mm have been considered as having high myopia.^{5,6}

Given that virtually no published data is available addressing the relationship between AXL and type of cataract, we chose to study this relationship using a clinic-based sample. We designed an observational clinic-based case-control study to investigate the prevalence of different types and densities of age-related cataracts in subjects with high myopia (as determined by AXL) and emmetropia. To the best of our knowledge, this is the first study of its kind to document cataract prevalence using AXL rather than refractive error as the criterion to define high myopia and emmetropia. In addition, although most published literature has reported an association between refractive myopia and type of cataract, the relationship between myopia and cataract density has not been reported.

METHODS

A prospective observational case-control study was undertaken at Iladevi Cataract & IOL Research Center, Ahmedabad, India during the period September 2003 to April 2005. The study involved 800 eyes in the age group of 40 years and above with age-related cataracts. High myopia subjects with an AXL of 26.0 mm or more were designated as study cases ($n = 400$ eyes) and subjects with emmetropia with AXL ranging between 21.0 – 23.99 mm constituted the control cases ($n = 400$ eyes). Informed consent was obtained from all the subjects before enrolling them in the study. Healthy eyes with uncomplicated cataracts in the age group of 40 years and older were included in the study. Subjects with an AXL lower than 21.00 mm; those with an AXL between 24.00 to 25.99 mm; those using systemic or topical steroids for various reasons for more than three months; those with a history of intraocular surgery; ocular trauma; raised intraocular pressure; uveitis; pseudoexfoliation; diabetes mellitus; total cataract; LASIK/PRK; prophylactic laser photocoagulation; or cryo-treatment were excluded from the study. Subjects whose eyes could not attain a 7 mm dilation were also excluded from the study. Of 826 subjects examined, 8 subjects with AXL < 21 mm; 10 subjects with AXL between 24.0 – 25.99 mm; and 8 subjects with an AXL ≥ 27 mm, but with pupil dilation < 7 mm were excluded from the study. It took 18 months to enroll the subjects with high myopia while subjects with emmetropia were recruited within 12 months.

A pilot study conducted at our clinic showed the proportions of various types of cataract in subjects with high myopia (nuclear cataract 60%, PSC 35%, mixed cataract 40%) and emmetropia (nuclear cataract 40%, PSC 65%, mixed cataract 60%). With a sample size of 200 subjects per group, we would have a power of 80% with an alpha of 0.05. In this case, we would require 80 observations in the nuclear cataract group, 40 observations in the PSC group, and 80 observations in the mixed group. However, to ensure that we had an adequate sample size to draw a comparison between the proportions and other factors, we decided to take 400 subjects in each group.

An AXL measurement was taken before dilatation of the pupil. A trained observer recorded the observations and measurements for each eye. Ocular dimensions including AXL were

measured with an A-scan ultrasound device 835 (Humphrey Instruments, Inc., Palo Alto, CA, USA) with a high frequency (10 MHz) and low energy ultrasonic pulses emitted by the probe. AXL was determined until five acceptable values were generated for each eye and an average value was obtained from this.

After dilatation of the pupil with 1% tropicamide (Sunways Pvt Ltd, India) and 2.5% phenylephrine hydrochloride (Sunways Pvt Ltd, India) eye drops, a single observer examined the patient with a slit-lamp, and detail of lens opacity was documented (absence or presence, and if present - type of cataract and density of nuclear cataract). A single observer was used to avoid bias and to maintain reliability and consistency. The methodology adopted for evaluating the type and density of the cataract was standardized in terms of illumination and magnification. The type of cataract was categorized in the following manner: nuclear, cortical, PSC and a combination of these as mixed cataract. A clear lens assessment was done using oblique illumination. Nuclear cataract was observed under oblique illumination and a slit beam was fixed at 1 mm width and 14 mm height, with 12x magnification when the slit-lamp was placed at an angle of 30 to 45 degrees. Retroillumination was used to assess cortical cataract and PSC cataract. The retroillumination slit-lamp beam was fixed at 1 mm width, 14 mm height, and using a 12x magnification. The illumination was kept at 100%. The cortical and PSC cataract opacities appeared as darkly shaded interruptions of reddish-orange reflex⁷. The observations were recorded using a video camera (Image Archiving System, Carl Zeiss, Jena, Germany) attached to a slit-lamp (SL 120; Carl Zeiss) keeping the illumination at 100%. A trained observer recorded the observations and measurements for each eye. The density of the nucleus was measured according to the Emery and Little classification.⁸ The rating scheme for nuclear density was primarily based on the consistency/color of the nucleus: grade 1: soft; grade 2: semi-soft (white, or yellowish white or yellowish green); grade 3: medium (yellow); grade 4: hard nuclei (amber color); grade 5: rock hard (black color or brunescent).

We carried out an analysis of the prevalence of each cataract type in subjects with high myopia and emmetropia, and the resulting odds ratio (OR) and 95% confidence intervals (CI) are presented for the two groups. We analyzed the probability of occurrence of a nuclear cataract with other types of cataract in subjects with high myopia and those with emmetropia. We also studied the probability of occurrence of nuclear cataract and PSC with other types of cataract; and nuclear cataract versus PSC in subjects with high myopia and emmetropia, particularly in the age group below 49 years. We also carried out an analysis of the prevalence of different types of cataract according to AXL measurements in subjects with high myopia only. Further, we analyzed the density of nuclear cataract in both subjects with high myopia and emmetropia after adjusting for patient age. SPSS statistical software package (version 10.0, SPSS Inc., Chicago, IL, USA) was used for analysis.

RESULTS

The 800 eyes studied (mean age 58.54 ± 9.4 years, range 41 – 80 years) included 458 eyes from male and 342 from female patients. Of the 458 eyes from males, 256 eyes were in the high myopia group and 202 eyes were emmetropes; similarly, of the 342 eyes from females, 144 eyes were in high myopia group and 198 eyes were emmetropes. The mean AXL was 27.9 ± 1.5 mm in subjects with high myopia and 22.1 ± 1.0 mm in those with emmetropia. The mean age of subjects with high myopia was 57.8 ± 9.5 years, and 57.2 ± 9.3 years in the emmetropia group. The prevalence of different types of cataract between subjects with high myopia and emmetropia is depicted in Table 1. In subjects belonging to all age groups, nuclear cataract was more often encountered ($P < 0.001$) in high myopia patients than in those with emmetropia. A meaningful analysis of the prevalence of cortical cataract was not possible as the numbers detected were very small. On the whole, PSC and mixed cataracts were encountered more often ($P < 0.001$) in subjects with emmetropia than in those with high myopia. However, this was

not significantly different for subjects with nuclear cataract and PSC ($P = 0.290$). Overall, when all the age groups are considered together, subjects with high myopia are more likely to have a nuclear cataract than those with emmetropia (OR 3.8, 95% CI 2.9 – 5.2). Similarly, when all the age groups are considered together, subjects with emmetropia are more likely to have PSC than those with high myopia (OR, 1.43 95% CI 1.14 – 1.81). The prevalence of cataract type between genders (Table 2) and different age groups (Table 3) are each compared in subjects with high myopia and emmetropia. The prevalence of nuclear cataract was higher ($P < 0.001$) in subjects with high myopia with an increase in AXL when compared with other types of cataract attaining statistical significance (Table 4). Analysis of different densities of cataract in subjects with high myopia and emmetropia after adjusting for age is depicted in Table 5. In all the age groups, a nuclear density of grade 3 or higher was encountered significantly more often ($P \geq 0.003$) in subjects with high myopia than in those with emmetropia. Furthermore, the probability of the occurrence of a higher density of cataract was more in subjects with high myopia than in those with emmetropia (OR = 6.5, 95% CI 4.5 – 9.2). In subjects with high myopia, in the age group below 49 years, there was a greater probability of occurrence of a higher density of cataract by 1.24-times when compared with the age group of 50 years and above (OR = 1.24, 95% CI 0.62–2.51). In subjects with high myopia, we observed that with an increase in AXL, there was a higher incidence of high-density cataracts greater than or equal to grade 3 (Table 6).

DISCUSSION

Only a few population-based studies have attempted a detailed evaluation of the relationship between myopia and the type of cataract.^{9,10} The association between high myopia and cataract has been well established¹¹ and an association between simple myopia and cataract has been suggested.^{1,2,11} Anecdotal evidence and clinic-based studies have suggested that myopia, particularly severe and pathologic myopia, may increase the risk of cataract.^{1,2,11} The visual impairment project demonstrated a strong cross-sectional association between myopia and nuclear opacity.^{12,13}

Considerable variation exists in published literature regarding what constitutes high myopia. Some authors refer to the refractive error of the eye,^{14,15} while others refer to the power of the implanted IOL.⁵ In some studies,^{5,6} an AXL of 25 mm was used to define high myopia. In another study,¹⁶ high myopia was defined as an AXL of 26.5 mm or more. We have defined high myopia as an AXL of ≥ 26 mm. Reliable population-based epidemiological data on the prevalence of cataract in reference to AXL is not available in India. Our data from this clinic-based study, in spite of its selection bias is perhaps one of the largest bodies of epidemiological data on this topic from India. In the present study, we have described only the prevalence of different types of cataract in relation to AXL. We did not, however, address the issue of the patients' accessibility to cataract surgery.

The majority of the subjects with cataract in our series of high myopia were in the age group of 50–59 years. In another report,¹⁷ a higher incidence of cataract was noted in subjects with high myopia in the age group of 50–59 years when compared with other types of refractive error. In the present series, there was a predominance of men in the high myopia group. Similar observations regarding male preponderance were stated in a report¹⁸ on subjects with high myopia undergoing cataract surgery. In our present study of the high myopia group, we found an association between nuclear cataract and PSC, but none between cortical cataract and PSC. The Beaver Dam Eye Study¹⁹ revealed that when age and gender data were adjusted in patients with myopia who had incurred different types of cataract, myopia was strongly related to nuclear cataract and PSC, but not to cortical cataract.

The association between nuclear cataract and myopia has been demonstrated in several population-based studies among adults of different ethnicities.^{20,21} In our series on high myopia, we found a significant association between high myopia and nuclear cataract (OR: 3.8, 95% CI 2.9 – 5.2). The Blue Mountains Eye Study⁹ made a similar observation (OR: 3.3%; 95% CI 1.5 – 7.4). In our series of subjects between 40 – 50 years of age, nuclear sclerosis was predominant. In another study¹⁸ of subjects undergoing cataract surgery, the authors reported a preponderance of nuclear sclerotic cataracts in young subjects with high myopia. Early onset of nuclear sclerosis has been described in another report as well.²² The relationship between myopia and PSC is controversial. Unlike nuclear cataract, however, PSC does not appreciably effect refraction. Therefore, it has been suggested that this relationship may be causal and myopia may be a risk factor for the development of PSC.²³ While PSC was not associated with high myopia in our series, a relationship between PSC and high myopia has been described in other studies.^{9,23} This premise is supported by findings from the Blue Mountains Eye Study³ in which myopic refraction and early onset myopia were related to the increased odds for the occurrence of PSC. The Blue Mountains Eye Study³ supports the premise that long-standing myopia is an independent risk factor for age-related cataract, particularly PSC. In our series, the prevalence of PSC in the high myopia group was 6%, while this figure ranged from 24%¹¹ to 40%¹ in other studies. In our series, no association was observed between cortical cataract and high myopia. Similar observations on the association between high myopia and cortical cataract have been reported in other studies.¹³ In the present study, in subjects less than 49 years of age, the cataract density was higher in eyes with high myopia compared with those eyes with emmetropia. However, we found a statistically significant difference in the cataract density among subjects with high myopia and emmetropia; and, as we expected, the occurrence of nuclear cataract was higher with the high myopia group. O'Donnell and Maumenee²⁴ first described cataract as discrete nuclear sclerosis in young subjects with axial myopia and nuclear sclerotic cataract as the cause of unexplained visual loss in subjects with axial myopia. Kaufman and Sugar,²² in their series on young subjects with high myopia, described the early onset of discrete nuclear sclerotic cataract. To our knowledge, few studies to date have proposed different mechanisms for cataract formation in the high myopia group.

Our study has important implications. The observations documented in our clinic-based study merit detailed evaluation at the community level to gain an increased understanding of this problem. The relationship between axial myopia and the onset of cataract in young individuals is clearly established. The density of cataract was higher in the high myopia group. The strength of our study is that we have defined myopia with an axial measurement rather than with a refractive measurement and also that we have reported the grade of nuclear cataract. We used standardized methods to measure AXL and to establish the density of cataract during data collection. The limitations of this study should also be considered. It was not possible to determine the temporal relationship between AXL and the type or density of cataract because of the cross-sectional nature of the study. Being a clinic-based population study, there may have been a bias during selection. The examiner knew the AXL measurements when observing the type and density of cataract. In a few subjects belonging to the high myopia group, there may have been an error in the AXL measurement due to the presence of a posterior staphyloma. However, these subjects with high myopia were included in the study and we did not recheck the AXL with a B-scan. We did not follow the protocol of the LOCS (lens opacification classification system) when establishing the type and density of the cataract.

In conclusion, it can be stated that nuclear cataract was strongly associated with axial myopia. The density of the nuclear cataract was higher in subjects with myopia. No association was observed between PSC and cortical cataract in the high axial myopia group.

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Biography

M.R. Praveen DOMS is a junior consultant at the Iladevi Cataract & IOL Research Centre. Dr Praveen's interest includes epidemiology of age-related cataract and management of cataract.

Table 1

Prevalence of different types of cataracts in high myopic and emmetropic group.

Type of cataract	High Myopic Eyes n (%)	Emmetropic eyes n (%)	Significance
Nuclear	248 (62.0%)	118 (29.5%)	<i>P</i><0.001
Cortical	2 (0.5%)	14 (3.5%)	<i>P</i><0.001
PSC	24 (6.0%)	54 (13.5%)	<i>P</i><0.001
Nuclear + PSC	74 (18.5%)	82 (20.5%)	<i>P</i> =0.290
Mixed (nuclear + cortical + PSC)	52 (13.0%)	132 (33.0%)	<i>P</i><0.001

PSC, posterior subcapsular; n = number of eyes.

Table 2

Prevalence of different types of cataracts between genders high myopic and emmetropic group.

Type of Cataract	Gender	High Myopic eyes n (%)	Emmetropic eyes n (%)	Significance
Nuclear	Male	170 (73.9%)	60 (26.1%)	<i>P</i> < 0.001
	Female	78 (57.4%)	58 (42.6%)	
Cortical	Male	2 (33.3%)	4 (66.7%)	<i>P</i> = 0.051
	Female	0	10 (100%)	
PSC	Male	14 (29.2%)	34 (70.8%)	<i>P</i> =0.698
	Female	10 (33.3%)	20 (66.7%)	
Nuclear + PSC	Male	42 (48.8%)	44 (51.2%)	<i>P</i> =0.698
	Female	32 (45.7%)	38 (54.3%)	
Mixed (nuclear + cortical + PSC)	Male	28 (31.8%)	60 (68.2%)	<i>P</i> =0.305
	Female	24 (25.0%)	72 (75.0%)	

PSC, posterior subcapsular cataract; n = number of eyes

Table 3
Prevalence of different types of cataracts in different age groups high myopic and emmetropic group.

Type of cataract	<49 yrs of age		50 – 59 yrs of age		60 – 69 yrs of age		>70 yrs of age	
	H.Myopia	Emmetropia	H.Myopia	Emmetropia	H.Myopia	Emmetropia	H.Myopia	Emmetropia
Nuclear	46 (65.7%)	14 (21.2%)	98 (64.5%)	46 (35.4%)	76 (63.3%)	42 (28.8%)	28 (48.3%)	16 (27.6%)
Cortical	0	4 (6.1%)	0	2 (1.5%)	0	6 (4.1%)	2 (3.4%)	2 (3.4%)
PSC	12 (17.1%)	28 (42.4%)	8 (5.3%)	18 (13.8%)	4 (3.3%)	8 (5.5%)	0	0
Nuclear + PSC	12 (17.1%)	16 (24.2%)	32 (21.1%)	24 (18.5%)	20 (16.7%)	30 (20.5%)	10 (17.2%)	12 (20.7%)
Mixed (nuclear + cortical + PSC)	0	4 (6.1%)	14 (9.2%)	40 (30.8%)	20 (16.7%)	60 (41.1%)	18 (31.0%)	28 (48.3%)

$P < 0.001$

PSC, posterior subcapsular cataract; H.Myopia, High Myopia; yrs = years.

Table 4

Prevalence of different types of cataracts in high myopic eyes with increase in axial length

Type	26–26.99 mm	27–27.99 mm	28.00–28.99mm	>29 mm
Nuclear	58 (41.8%)	78 (75.0%)	82 (69.5%)	30 (71.4%)
Cortical	2 (1.5%)	0	0	0
PSC	10 (7.5%)	2 (1.9%)	10 (8.5%)	2 (4.8%)
Nuclear + PSC	34 (25.4%)	20 (19.2%)	14 (11.9%)	6 (14.3%)
Mixed (nuclear+ cortical + PSC)	32 (23.9%)	4 (3.8%)	12 (10.2%)	4 (9.5%)

PSC: posterior subcapsular cataract;

P<0.001

TABLE 5
Prevalence of different grades of cataracts in different age groups in high myopic and emmetropic group.

	40–49 yrs		50–59 yrs		60–69 yrs		70–79 yrs	
	<Grade3	≥Grade3	<Grade3	≥Grade3	<Grade3	≥Grade3	<Grade3	≥Grade3
H.Myopia N=358 eyes	12(20.7%)	46(79.3%)	26(20.0%)	104(80.0%)	14(12.1%)	102(87.9%)	12(22.2%)	42(77.8%)
Emmetropia N=324 eyes	30(68.2%)	14(31.8%)	60(53.6%)	52(46.4%)	76(62.3%)	46(37.7%)	24(52.2%)	22(47.8%)
	P<0.001		P<0.001		P<0.001		P=0.003	

H.Myopia=High Myopia

TABLE 6

Prevalence of different grades of cataracts according to axial length in high myopic group

AXL	<Grade 3	>Grade 3
26–26.99 mm	18 (16.4%)	94 (84.6%)
27–27.99 mm	24 (24.5%)	74 (75.5%)
28–28.99 mm	22 (20.4%)	86 (79.6%)
>29	0	40 (100%)

AXL: Axial length

 $P<0.001$