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SCIENTIFIC REPORT

Visual outcomes for high myopic patients with or without myopic maculopathy: a 10 year follow up study

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Aim: To evaluate the visual outcomes for high myopic patients aged 40 years and older with or without myopic maculopathy.

Methods: 552 high myopic (spherical equivalent $\leqslant -6.0$D or axial length $\geqslant 26.5$ mm) patients were enrolled in the study, 230 cases with myopic maculopathy (at least lacquer cracks were identified) and 322 cases without maculopathy. The initial and final visual acuity (VA) (after 10 years) was compared between two groups. Additionally, the relation between sex, age, refraction, and axial length was analysed to find out the possible risk factors associated with visual outcome in myopic maculopathy.

Results: In 92% of patients aged 40–49, final VA was better than 20/40 after 10 years of follow up. However, it was less than 40% in those older than 60 years. For more than 50% of patients older than 40 years of age with maculopathy, their vision had decreased more than two lines in Snellen VA after 10 years of follow up, compared to only 4.3% of analogues without myopic maculopathy. Patchy atrophy and choroidal neovascularisation in myopic macular degeneration groups showed poorer visual outcome than lacquer cracks in the macular lesion group. Other prognostic factors of visual outcomes were myopic refraction, axial length, and ageing.

Conclusions: Clearly, prognosis for patients with maculopathy is poorer than for those without maculopathy. Refractive status, axial length, and ageing are the main factors involved in determining the visual outcomes. The macular grading also affects the visual outcome for high myopic patients.

The prevalence of myopia appeared to have progressively increased year by year around the world.[1–4] The prevalence of high myopia ($\leqslant -6.0$D) has also apparently increased levels for senior high school children 18 year olds of 16% (1995)[5] and 21% (2000),[6] respectively, in Taiwan. High myopia is a major cause of legal blindness in many developed countries.[7] In a detailed study of visual disability in the United States, the National Eye Institute (1976), found myopia to be the fifth most frequent specific cause of impaired vision, the eighth most frequent cause of severe visual impairment, and the seventh most frequent cause of legal blindness.[8] A study by the National Society for the Prevention of Blindness also found that myopia was the seventh most common cause of blindness in patients aged 20 years and over.[9]

High myopia is associated with progressive elongation of the eyeball. As a result of excessive eyeball elongation, various complications may develop.[10–13] Clinically, the funduscopic changes associated with high myopia include straightened and stretched vessels, temporal peripapillary atrophic crescent, tilting of the optic disc, posterior staphyloma, lacquer cracks in the Bruch's membrane, geographic areas of atrophy of the retinal pigment epithelium and choroids, subretinal haemorrhage, and choroidal neovascularisation (CNV). Of great importance is the severe reduction in corrected vision that is associated with the CNV.[14–16] Clinical and histopathological studies have documented CNV in 5% to 10% of eyes with pathological myopia.[17 18] A number of papers report prevalence of myopic degeneration at about 1% in the general population in Asia.[19] The impact of myopic retinopathy on visual impairment is important because it is often bilateral and irreversible, and it frequently affects individuals during their productive years.

Myopic retinopathy is an important cause of visual impairment. Most studies report visual outcomes for high myopic eyes with CNV[10–13 20–24]; however, there are several types of macular degeneration in high myopic eyes, with varying visual prognosis demonstrated. The purpose of this study, therefore, was to compare the prognostic factors and visual outcomes of highly myopic eyes with and without maculopathy among middle aged and older adults.

MATERIAL AND METHODS

Sampling methods

This is a retrospective study. The study protocol was approved by the joint committee for clinical investigation at the National Taiwan University School of Medicine. We retrospectively reviewed the high myopic (spherical equivalent $\leqslant -6.0$D, or axial length $\geqslant 26.5$ mm) patients who were followed up at the high myopia clinic at the National Taiwan University Hospital every 6 months for more than 10 years. Patients younger than 40 years of age, who had previous laser treatment for macular lesion, and history of retinal detachment surgery or glaucoma were excluded from the study. In total, 552 high myopic and middle aged ($\geqslant$40 years) patients were enrolled. The worse eye was chosen for study. Patients' medical and photographic records were reviewed for data, including demographic characteristics, refraction, biometric axial length, best corrected Snellen visual acuity (VA), and the characteristics of macular conditions. The severity of the myopic macular chorioretinal condition (Grade Mn) was categorised according to Avila *et al*.[14] The degree of myopic macular chorioretinal change was graded on a scale of increasing severity from 0 to 5 as follows: M0: normal appearing posterior pole, no tessellation pattern in macular area; M1: tessellation and choroidal pallor pattern in macular area; M2: choroidal pallor and tessellation, and the border of an ectasia posterior were visualised; M3: choroidal pallor and tessellation, with several yellowish lacquer cracks in Bruch's membrane and posterior staphyloma were visualised; M4: choroidal pallor and tessellation, with lacquer cracks and posterior staphyloma, and focal areas of deep choroidal atrophy were visualised; M5: choroidal pallor and tessellation

Abbreviations: CNV, choroidal neovascularisation; logMAR, logarithms of the minimum angle of resolution; VA, visual acuity

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with lacquer cracks, posterior staphyloma, geographic areas of atrophy of retinal pigment epithelium and choroids, and CNV were visualised.

Examination and calculation

The refractive status was measured by using an autorefractometer (Topcon RK-3000, Tokyo, Japan). The cycloplegic refraction was measured 30 minutes subsequent to the last of three successive drops of 1% tropicamide having been introduced into eyes at 5 minute intervals. The biometric axial length (including anterior chamber depth, lens thickness, and total axial length) was measured by A-scan ultrasonography (Sonomed A-1500). Three separate measurements were recorded for each procedure, and the means were calculated. The Snellen VA data were transformed into equivalent logarithms of the minimum angle of resolution (logMAR) values. In the present study, we defined the myopic macular condition greater than M3 as ''with maculopathy,'' less than M2 as ''without maculopathy.'' We compared various factors between ''with maculopathy'' and ''without maculopathy'' by using a t test or χ^2 test. A p value of less than 0.01 was considered statistically significant. We also used multiple logistic regression analyses to evaluate the effects of age, sex, and axial length on the grading of myopic maculopathy.

RESULTS

The demographic features of the sample population of 323 females (59.6%) and 229 males (40.4%) are summarised in table 1. Distribution of myopic macular grading in the studied eyes is presented in table 2. Macular grading was greater than M1 for all subjects aged over 40 years. Sex distribution was similar for each grade, with grade distributions in table 2. Additionally, we found that incidence of high myopic eyes, ''without maculopathy'' (M1 and M2), decreased with age, while the rate for those eyes ''with maculopathy'' (M3, M4, and M5) increased with age.

The initial and final best visual acuities (after 10 years follow up) are presented in table 3. The incidence of subjects with best corrected vision better than 20/40, for both initial and final VA, decreased with age. For 95% of subjects aged 40–49 years, initial VA was better than 20/40. Around 92% of this age group, final VA remained better than 20/40 after 10 years of follow up. However, less than 40% of patients aged 60–69 years had final VA of 20/40 or better. Only 20% of those aged over 70 years showed best corrected vision of 20/40. Moreover, around 26% of patients aged over 70 years had best corrected vision worse than 20/200.

We also found that VA was worse than two lines in Snellen VA for more than 50% of maculopathy eyes (M3, M4, and M5 groups) after 10 years, especially in subgroups older than

Table 1 Age distribution in high myopic patients

Age (years)	Males	Females	Total
40–49	79	120	199 (36.1%)
50–59	59	76	135 (24.4%)
60–69	48	59	107 (19.4%)
>70	43	68	111 (20.1%)
Total	229 (40.4%)	323 (59.6%)	552 (100%)

Table 2 Distribution of myopic macular grading in different age groups

	40–49 M/F	50–59 M/F	60–69 M/F	⩾70 M/F	Total
M1	21/25	0/0	0/0	0/0	21/25
	(23.1%)	(0%)	(0%)	(0%)	46
M2	66/72	31/48	17/21	8/13	122/154
	(69.4%)	(58.5%)	(35.5%)	(18.9%)	276
M3	6/6	14/18	15/21	16/32	51/77
	(6%)	(23.7%)	(33.6%)	(43.2%)	128
M4	0/2	7/8	7/12	11/21	25/43
	(1%)	(11.1%)	(17.8%)	(28.8%)	68
M5	0/1	2/7	6/8	2/8	10/24
	(0.5%)	(6.7%)	(13.1%)	(9.1%)	34
Total	93/106	54/81	45/62	37/74	552
	(100%)	(100%)	(100%)	(100%)	

Table 3 Changes in best corrected VA among different age groups during follow up

	40–49 (n = 199)	50–59 (n = 135)	60–69 (n = 107)	⩾70 (n = 111)
Initial VA				
⩾20/40	188 (94.5%)	110 (81.5%)	65 (60.7%)	31 (27.9%)
20/40–20/200	9 (4.5%)	18 (13.3%)	31 (29.0%)	63 (56.8%)
⩽20/200	2 (1.0%)	7 (5.2%)	11 (10.3%)	17 (15.3%)
Final VA				
⩾20/40	183 (91.9%)	84 (62.2%)	39 (36.4%)	21 (18.9%)
20/40–20/200	13 (6.5%)	40 (29.6%)	51 (47.7%)	61 (54.9%)
⩽20/200	3 (1.6%)	11 (8.2%)	17 (15.9%)	29 (26.2%)

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50 years (table 4). Only 4% of those eyes without maculopathy (M1 and M2 groups), had comparable visual after 10 years. There was no significant difference in the incidence of VA worse than two lines in Snellen VA comparing M4 (73.5%) and M5 (76.5%) subgroups ($p>0.1$). However, this compromised VA was significantly lower for the M3 subgroup (53.1%) relative to the M4 and M5 subgroups ($p<0.05$). Further, final VA was less than 20/200 for 20 of 34 cases (58.8%) with CNV in the M5 subgroup.

Among 34 cases of vision decreased to the level of 20/40 to 20/200 in M2 group. Twenty two cases progressed from M2 to M3 during 10 years follow up, another 12 cases were caused by active stage of simple haemorrhage. Among the M3 group, there were 28 new cases where vision drop to the level of 20/40–20/200. The macular grading in those cases was still in the M3 grade. The other five new cases with vision less than 20/200 were the result of CNV. Among the M4 group, nine cases of vision decreasing from 20/40–20/200 to less than 20/200 were caused by the CNV. Besides, 19 new cases, in the M5 group, of vision decreased to less than 20/200 were caused by CNV (table 5).

We also demonstrated a statistically significantly difference on final VA and age, refractive status, and axial length between groups with and without maculopathy (table 6). Eyes with maculopathy have a higher myopic refraction (−12.8D) and longer axial length (28.8 mm) than those eyes without maculopathy (−9.4D, 26.7 mm). Multiple regression analysis (table 7) showed a significant difference in each grading of myopic maculopathy. Age and axial length were significant covariates ($p<0.05$, $p<0.001$, respectively).

DISCUSSION

In this study, the clinical course in terms of visual outcome was investigated for high myopic patients either with or without maculopathy. We analysed the visual prognosis for the different types of macular degeneration and its related factors. Initially, we noted that the incidence of cases ''without maculopathy'' decreased with the age while incidence of cases ''with maculopathy'' increased. Obviously, ageing is an important factor in the development of maculopathy.

Ageing also affects visual prognosis for high myopic patients. In our sample, we found that the incidence of best corrected vision better than 20/40 decreased with age. However, final VA remained better than 20/40 for most of those aged 40–49 years after 10 years of follow up. Thereafter, the incidence of this vision decreased with ageing. Furthermore, best corrected vision was lower than 20/200 in approximately one quarter of patients aged over 70 years. Tokoro[19] also noted that 95% of eyes with tessellated fundus had VA greater than 20/40 in his study.

Further, macular grading in high myopia also associated with visual prognosis. Visual acuity was worse than two lines in Snellen VA for only 4% of the ''without maculopathy'' group after 10 years in our study. In the M2 group, among 34 cases vision decreased to 20/40–20/200; 22 cases progressed from M2 to M3, the other 12 cases had the active stage of simple haemorrhage.

In our study, there were 53% of cases worse than two lines in the M3 group (lacquer cracks). Among the M3 group, we found 28 new cases where vision dropped to 20/40–20/200.

Table 4 Changes of visual acuity (the proportion of VA worse than two lines) during follow up period

Age (years)	M1	M2	M3	M4	M5
40–49	0/46 (0%)	1/138 (0.7%)	3/12 (25%)	1/2 (50%)	1/1 (100%)
50–59	0 (0%)	4/79 (5.1%)	15/32 (46.9%)	9/15 (60%)	6/9 (66.7%)
60–69	0 (0%)	3/38 (7.9%)	22/37 (59.5%)	15/19 (78.9%)	11/14 (78.6%)
⩾70	0 (0%)	4/21 (19.0%)	28/47 (59.6%)	25/32 (78.1%)	8/10 (80%)
Total	0/46 (0%)	12/276 (4.3%)	68/128 (53.1%)	50/68 (73.5%)	26/34 (76.5%)

Table 5 Changes of best corrected visual acuity among different macular grading groups during follow up

	⩾20/40 initial (10 years)	20/40–20/200 initial (10 years)	⩽20/200 initial (10 years)
M1	46 (46)	0 (0)	0 (0)
M2	276 (242)	0 (34)	0 (0)
M3	72 (39)	56 (94)	0 (5)
M4	0 (0)	41 (32)	27 (36)
M5	0 (0)	24 (5)	10 (29)

Table 6 Characteristics of study eyes with and without maculopathy

Characteristic	With maculopathy (n = 230)	Without maculopathy (n = 332)	p Value
Sex (M/F)	86/144	143/179	0.13
Age (years)	62.2 (8.4)	51.9 (11.7)	0.007
Refractive error (D)	−12.8 (2.7)	−9.4 (4.3)	0.001
Axial length (mm)	28.8 (1.3)	26.7(2.2)	0.006
Initial visual acuity	0.57(0.8)	0.31 (0.4)	0.02
Final visual acuity	0.94(0.7)	0.33 (0.5)	0.007

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Table 7 The coefficients and standard errors (SE) of multiple linear regression on the different grading of myopic maculopathy

	Logit (M3/M2)		Logist (M4/M2)		Logist (M5/M2)	
Covariate	Coefficient	SE	Coefficient	SE	Coefficient	SE
Intercept	−24.922	1.973	−56.685	3.119	−33.453	4.782
Sex (1: male)	−1.38	0.918	−1.23-	0.961	−1.45	0.893
Age (10 years)	0.1339*	0.0088	0.1606*	0.0106	0.1342*	0.0153
Axial length (1 mm)	1.339**	0.0892	1.7435**	0.1042	0.9458**	0.1678

*p<0.01, **p<0.001.

The macular grading of those cases was still the M3 grade. The other five new cases with vision less than 20/200 were caused by CNV. Lacquer cracks, which are yellowish linear lesions found in the posterior of high myopic eyes, are an earlier sign of myopic maculopathy. Pathological myopia even without any chorioretinal degeneration has been shown to be an early functional impairment of the outer retina when studied by electrophysiological and psychophysiological methods.[25–29] Also, retinal pigment epithelium dysfunction has been suggested in high myopic eyes.[30–32] In Tokoro's study[19] lacquer cracks are suggested not to influence VA, except when they cross the fovea.

Among the M4 group, nine cases of vision decreasing from 20/40–20/200 to less than 20/200 were caused by CNV. In the M5 group,19 new cases of vision decreasing to less than 20/200 were the result of CNV. Chorioretinal atrophy accompanied by CNV is the main cause of vision loss in high myopia. CNV is frequently associated with other features of myopic degeneration, such as peripapillary chorioretinal atrophy and lacquer cracks.[33 34] However, the visual prognosis of myopic CNV is not always consistent. Previously, studies of VA outcomes for CNV associated with high myopia have included both young and old patients.[14–16 20 22 23] Older age is associated with poor initial and final VA. In our study, most of the patients were aged 50 years or over, with final VA below 20/200 in about 60% of the cases. Avila *et al*[14] also reported a final VA of 20/200 or less in 60% of the eyes after a mean follow up period of 41 months. In another study of 27 eyes with myopic CNV, the final VA dropped to 20/200 or less in 88.9% and 96.3% of cases at 5 years and 10 years after onset, respectively.[24] Therefore, aging remains the most important factor affecting visual prognosis for myopic patients. Ageing may affect retinal pigment epithelium function.[35] Older patients with high myopia are expected to have more widespread retinal pigment epithelium dysfunction than younger subjects.

We found that VA was worse by two lines for about three quarters of the M4 and M5 subgroups after 10 years. We expect that this is due to the development and enlargement of chorioretinal atrophy around the regressed CNV in the M5 group. Chorioretinal atrophy typically develops in the perifovea, with some cases involving the macular centre. However, Ito-Ohara *et al*[36] reported that 60% of patchy chorioretinal atrophy in marginal regions of posterior staphyloma spread towards the centre and 70% of the lesions of patchy chorioretinal atrophy in the macular area spread in all directions after long term follow up. Besides, new chorioretinal atrophy was also observed after resolution of a Fuchs' spot. Tokoro[19] also suggested an enlarged lesion of diffuse atrophy in macula. Therefore, we thought that chorioretinal atrophy in the macular area may be another prognostic factor to predict deterioration in VA. Besides, foveoschisis could be another major factor for visual decrease in high myopic eyes.[37 38]

We also demonstrated statistically significantly difference in final VA, age, refractive status, and axial length between groups with and without maculopathy. Multiple regression analysis also showed age and axial length were significant covariates. In summary, our long term observations suggested that visual outcome for older high myopic patients with maculopathy tend to be poorer than that for younger patients. Refractive status, ageing, and axial length appear to be the main factors determining visual outcome. The mean myopic refraction of eyes with myopic maculopathy was −12.8D and axial length was 28.8 mm. The macular grading also affects visual outcome in high myopic patients. Recognition of these patterns is essential for early diagnosis and treatment, and early referral for rehabilitation.

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