Original Article

Variant myopia: A new presentation?

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Purpose: Variant myopia (VM) presents as a discrepancy of >1 diopter (D) between subjective and objective refraction, without the presence of any accommodative dysfunction. The purpose of this study is to create a clinical profile of VM. **Methods:** Fourteen eyes of 12 VM patients who had a discrepancy of >1D between retinoscopy and subjective acceptance under both cycloplegic and noncycloplegic conditions were included in the study. Fourteen eyes of 14 age- and refractive error-matched participants served as controls. Potential participants underwent a comprehensive orthoptic examination followed by retinoscopy (Ret), closed-field autorefractor (CA), subjective acceptance (SA), choroidal and retinal thickness, ocular biometry, and higher order spherical aberrations measurements. **Results:** In the VM eyes, a statistically and clinically significant difference was noted between the Ret and CA and Ret and SA under both cycloplegic and noncycloplegic conditions (multivariate repeated measures analysis of variance, $P < 0.0001$). A statistically significant difference was observed between the VM eyes, non-VM eyes, and controls for choroidal thickness in all the quadrants (Univariate ANOVA $P < 0.05$). The VM eyes had thinner choroids (197.21 ± 13.04 μ) compared to the non-VM eyes (249.25 ± 53.70 μ) and refractive error-matched controls (264.62 ± 12.53 μ). No statistically significant differences between groups in root mean square of total higher order aberrations and spherical aberration were observed. **Conclusion:** Accommodative etiology does not play a role in the refractive discrepancy seen in individuals with the variant myopic presentation. These individuals have thinner choroids in the eye with variant myopic presentation compared to the fellow eyes and controls. Hypotheses and clinical implications of variant myopia are discussed.

Access this article online

Website: www.ijo.in

DOI: 10.4103/ijo.IJO_1115_17

Quick Response Code:

Key words: Autorefractor, cycloplegic refraction, myopia, retinoscopy

Pseudomyopia is a transient form of myopia and presents as a more myopic subjective refraction compared to the corresponding objective refraction.[1,2] There are various conditions that may lead to a pseudomyopic presentation including accommodative spasm (AS), acquired brain injury, and factors such as excessive near work, uncorrected hypermetropia, intermittent exotropia, and emotional/psychogenic illness.[1-4] Pseudomyopia is best treated with cycloplegic agents. If resolution does not occur with a short course of cycloplegics, a longer duration is recommended.[4,5]

The refractive discrepancy in pseudomyopia is generally >2–3D in magnitude.[1-4] In our clinical experience, we have often noticed discrepancies between retinoscopy and subjective refraction of >1 diopter but perhaps less than that expected with pseudomyopia. We have attempted to treat them as pseudomyopia; however, the discrepancy continued to exist under cycloplegia and the patients did not respond to treatment with cycloplegic agents.

In the absence of an AS, a discrepancy between subjective and objective refraction of larger than 1 D is seldom reported in human eyes, although it has been reported in rats and monkeys as a consequence of small eye artifacts.[6,7] Smaller discrepancies of <1 D could be attributed to factors such as artifacts caused by the instrumentation,[8] examiner's experience with retinoscopy,[9] influence of optical parameters such as aberrations and difference in the wavelengths used in the refraction techniques,[10-12] origin of the light reflection from different layers of the retina,[13] and off-axis retinoscopy.[14]

Based on our clinical findings, we report the clinical characteristics of this variant group of myopes who appear to show a discrepancy of >1D between retinoscopy and subjective refraction but do not have the clinical characteristics of pseudomyopia. The objective of the study was to compare the refractive and biometry parameters of this variant group of myopes with age and refractive error matched controls.

Methods

This study was conducted at a tertiary eye care center in India from January 2015 to June 2016. The institutional review board and the ethics committee of the institution approved the

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Manuscript received: 17.11.17; Revision accepted: 05.03.18

Cite this article as: Hussaindeen JR, Anand M, Sivaraman V, Ramani KK, Allen PM. Variant myopia: A new presentation?. Indian J Ophthalmol 2018;66:799-805.

research. The research adhered to the tenets of the Declaration of Helsinki. Written informed consent was obtained from all participants before enrolment. Consecutive participants who met the inclusion criteria were recruited for the study.

Subjects

Inclusion criteria for subjects with variant-myopia

- Age between 12 and 30 years
- Myopia ≥−0.50 DS as defined by subjective acceptance, with subjective acceptance ≥1.00D more myopic compared to cycloplegic retinoscopy
- Visual acuity >6/6
- Participants willing to undergo cycloplegic refraction
- Participants with any known ocular pathology, strabismus and/or amblyopia were excluded from the study.

Twelve participants who reported to the clinic during the study period with a >1D more myopic discrepancy between cycloplegic retinoscopy and subjective acceptance and who met the inclusion criteria were included in the study. Unilateral presentation was observed in 10 participants (3 in the right eye and 7 in the left eye) and bilateral presentation in 2 participants. Thus, the sample size of this study was 14 eyes.

Control subjects

All controls had VA of at least 6/6 in each eye. Fifty myopic patients who showed a discrepancy of <0.50D between retinoscopy and subjective refraction were screened. The cutoff of 0.50D discrepancy between retinoscopy and subjective acceptance has been clinically accepted for reliability and repeatability measurements when different refraction techniques are utilized.[15-19] The range of myopia of the 50 myopic patients was between −1.00DS and −8.00 DS. Out of the 50 participants, we matched 14 participants for age and refractive error and these participants served as the control group.

Procedures

Binocular vision assessment

Before enrolment, all participants underwent a detailed binocular vision assessment including standard clinical measurements of vergence and accommodation parameters, to rule out AS.[2-4] The tests included measurement of the amplitude of accommodation, accommodative response using monocular estimate method (MEM) retinoscopy, accommodative facility, relative accommodation, vergence amplitudes, vergence facility, dissociated phoria, and near point of convergence.

Objective and subjective refraction with and without cycloplegia

Without cycloplegia

Objective refraction using streak retinoscopy (Welch Allyn 18245) was performed by two experienced optometrists, masked to each other's findings, and the average of these values was taken as the starting point for subjective acceptance. The intraclass correlation coefficient (ICC) for these examiners was assessed before the beginning of the study. The right and left eyes of the patients were assessed by the respective eyes of the examiner to avoid off-axis retinoscopy error.[13] Off-axis retinoscopy error was also minimized by providing frequent reminders for the participants to fixate at the distant target and by appropriate interpupillary distance adjustment of the trial frame to ensure that retinoscopy was performed close to the visual axis. The examiner did not obstruct the target. The end point for retinoscopy was the point where a reversal reflex was noted. Subjective refraction was performed following retinoscopy and the minimum minus required consistent with maximum visual acuity was considered as the end point. The same examiner performed subjective acceptance for all participants using the average retinoscopy value as the starting point. To avoid any examiner bias, autorefraction using a Topcon KR 8900 autorefractor[17] was performed following subjective refraction. Three autorefractor readings were taken and the average spherical value of the refraction was taken for analysis.

With cycloplegia

Cycloplegic refraction was conducted on all participants 30 min after instillation of one drop of 1% Cyclopentolate Hydrochloride and one drop of 0.5% tropicamide.[20-22] The adequacy of cycloplegia was ensured by checking that there was no discrepancy between the distance and near refraction (0.4 m) with the open-field autorefractor (WAM 5500).[15] After cycloplegia, the subjective and objective refraction techniques were repeated exactly as before.

Axial length

Axial length was measured using an optical low-coherence reflectometry based biograph, the Allegro™ Biograph, and an average of three readings was documented.[23]

Aberrations

Aberrations were measured using an I-trace™ aberrometer that allows open-field viewing of an external target and thus minimizes instrument myopia.[24] Proper forehead and chin alignment and accurate distance fixation were ensured. Aberration measures were performed under cycloplegia, and the aberration values were scaled to a 5-mm pupil size.[25] Appropriate sign conventions were used for the right and left eye data as per the proposed standards for reporting the optical aberrations of eyes.[26] For data analysis, the total higher order aberrations (HOA) were computed from the root mean square (RMS) of 3rd to 6th order Zernike polynomials.

Retinal and choroidal thickness

The central and peripheral retinal and choroidal thickness was measured using a DRI optical coherence tomography (OCT) – 1 Atlantis swept source-OCT.[27,28] The change in retinal and choroidal thickness was measured at every 500-μ interval from the fovea up to 3 mm in the nasal, temporal, superior, and inferior quadrants.[28] The average of the six measurements for each quadrant was used for statistical analysis.

Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics for Windows, Version 21.0. (IBM Corp. Released 2012. Armonk, NY: IBM Corp.). The primary outcome measures (subjective refraction and axial length) were normally distributed and thus appropriate parametric statistical tests were used for analyses. An unpaired *t*-test was used to compare the age, refractive error, axial length, and radius of curvature between the cases and controls. Repeated measures-analysis of variance (RM-ANOVA) was used to compare the refractive differences between the three different refraction techniques (closed field autorefractor-CA, retinoscopy-Ret, and subjective acceptance-SA) under noncycloplegic and

cycloplegic conditions. Multivariate ANOVA was utilized for choroidal thickness, retinal thickness, and aberration comparisons. A $P < 0.05$ was considered statistically significant for the overall comparison and *post hoc* comparisons were conducted using a Bonferroni *post hoc* conservative *P* value.

Results

The age, refractive error, and biometry data are presented in Table 1. There was no statistically significant difference between the variant myopia (VM) cases and controls for age, refractive error, radius of curvature, and axial length (unpaired *t*-test $P > 0.05$). ICC for retinoscopy agreement between the examiners was calculated at the beginning of the study for 23 eyes and good agreement was found (ICC 0.99; 95% confidence interval [CI]: 0.98–0.99). A paired *t*-test for comparison of means of retinoscopy values between the two examiners did not reveal any statistically significant difference ($P = 0.52$).

Accommodation parameters in subjects with variant myopia

The accommodation parameters of the eyes with variant myopic presentation, other eyes of variant myopic cases, and controls are presented in Table 2. Except for accommodative amplitudes (one-way ANOVA, $P < 0.05$), the rest of the parameters were not statistically significantly different (one-way ANOVA, $P > 0.05$). The monocular accommodative facility, though low was comparable to myopes in other studies.[29]

Difference between refraction techniques

In control eyes

To compare the refractive estimates among different groups [Table 3], a multivariate RM ANOVA was used. The control group showed a significant difference between the dry refraction estimates ($P < 0.0001$; Wilk's $\Lambda = 0.630$; partial $\eta 2 = 0.57$). *Post hoc* Bonferroni showed a significant difference only between Ret and SA (mean difference ± spherical equivalent [SE]: 0.241 ± 0.04 D; 95% CI: 0.135 D to 0.347 D; $P < 0.001$). This difference was not clinically significant as the maximum difference observed was <0.50 D, which is within the test-retest repeatability of these measures, and also <1 D set as the criteria for refractive discrepancy in the study. No statistically significant difference was obtained between the cycloplegic and noncycloplegic refraction estimates [Fig. 1].

In subjects with variant myopia

Among patients with variant myopic presentation [Table 4], a statistically significant difference was noted between the refraction techniques ($P < 0.0001$; Wilk's $\Lambda = 0.186$; partial $\eta 2 = 0.908$). *Post hoc* Bonferroni pair-wise comparisons showed a statistically significant difference between Ret versus CA (Mean difference ± SE: 1.85 ± 0.13 D; 95% CI: 1.57–2.18 D, $P < 0.0001$) and Ret versus SA (Mean difference ± SE: 1.87 ± 0.12; 95% CI: 1.59–2.18; $P < 0.0001$ under non-cycloplegic conditions. The trend continued to exist even under cycloplegic conditions). No difference was observed between CA and SA. The difference between cycloplegic and noncycloplegic refraction was not statistically significant.

Fellow eyes of subjects with variant myopia

In the fellow eyes of patients with VM, a significant difference was noted between the dry and cycloplegic techniques (RM– ANOVA F (2, 17) = 7.442, $P = 0.005$; Wilk's $\Lambda = 0.533$; partial $\eta 2 = 0.467$) and *post hoc* Bonferroni showing a significant difference between Ret and SA (mean difference ± SE: 0.41 ± 0.10 D; 95% CI: 0.14 D to 0.68 D; $P = 0.003$). This difference again was less than the refractive discrepancy criteria set in the study and thus was considered clinically agreeable. There was no difference between the cycloplegic and noncycloplegic refraction estimates.

Comparison of higher order aberrations among subjects with variant myopic presentation and control myopic eyes

A multivariate test was performed to compare the HOA between patients with variant myopic presentation, fellow eyes of these patients and controls. As spherical aberration (SA) has the greatest effect on defocus and accommodation, the differences in SA between the groups were analyzed. There were no statistically significant differences between patients with VM and controls for the overall HOA and the mean RMS of spherical aberration (overall mean ± standard deviation (SD) HOA in microns: Eyes with variant myopic presentation: 0.53 ± 0.25; other eyes of VM: 0.43 ± 0.25; controls: 0.45 ± 0.16; SA mean ± SD: eyes with variant myopic presentation: 0.19 ± 0.09; other eyes of VM: 0.2 ± 0.14; controls: 0.18 ± 0.06; one-way ANOVA: $P > 0.05$) [Table 5].

Comparison of retinal and choroidal thickness between subjects with variant myopic presentation versus control myopic eyes

The retinal and choroidal thickness measurements were available for 12 variant eyes of cases, 13 controls and 8 nonvariant eyes of cases. Both within group and between-group differences were observed for these measurements among all the three categories.

A statistically significant within-group difference was observed for retinal thickness across superior, inferior, nasal, and temporal quadrants for both cases and controls (univariate ANOVA $P < 0.05$). The retinal thickness consistently followed the pattern of nasal > superior > inferior > temporal > central. For choroidal thickness, a significant difference was observed for choroidal thickness across different quadrants among the cases

Table 1: Subjective acceptance refraction values and biometry parameters of cases and controls

Parameters	Variant eye of cases (*n*=14 eyes)		Other eyes of cases (*n*=10 eyes)		Controls (*n*=14 eyes)	
	Mean±SD	Range	Mean±SD	Range	Mean±SD	Range
Age (years)	23±4	15-30			21±4	12-30
Spherical refractive error (D)	−5.27±1.76	−1.25--7.50	−3.78±2.48	0--7.50	−4.79±1.54	−1.50--7.25
AXL (mm)	25.56±1.22	23.86-27.38	25.31±1.28	23.31-27.34	24.84±0.69	23.83-26.27
Radius of curvature (mm)	7.62±0.31	7.05-8.06	7.71±0.29	7.05-8.04	7.59±0.18	7.30-7.87

SD: Standard deviation, AXL: Axial length

and controls that followed a consistent pattern of increasing thickness from superior quadrant followed by temporal, central, inferior, and nasal quadrants [Fig. 2].

Multivariate comparisons revealed a significant difference between the variant presentation eyes, nonvariant fellow eyes and controls ($F[5, 26] = 6.201$; $P < 0.0001$; Wilks' $\Lambda = 0.02$; partial $\eta 2 = 0.980$). *Post hoc* Bonferroni with conservative P value showed a significant difference between the variant eyes and control group in all quadrants except for the superior quadrant: mean difference ± SE (nasal quadrant: 73.54 ± 15.57 μ; 95% CI: 33.40–113.68 μ; $P < 0.0001$; temporal quadrant : 63.04 ± 17.15 μ; 95% CI: 19. 54–106.54 μ; $P = 0.003$; inferior quadrant: 90.58 ± 15.30 μ; 95% CI: 51.79–129.36 μ; $P < 0.0001$; central : 67.40 ± 18.93 μ; 95% CI: 19.39–115.425 μ; $P = 0.003$; superior quadrant: 61.2 ± 24.6 μ; 95% CI: 1.5–124 μ; $P = 0.05$). There was no significant difference between nonvariant eyes and control eyes across all the quadrants.

Table 2: Accommodation parameters of both eyes of patients with a variant myopic presentation

Binocular vision parameters (units)	Mean±SD		
	Eyes of patients with variant myopic presentation	Fellow eyes of patients with variant myopic presentation	Controls
AA (D)	13.7±2.2	13.8±2.9	11±3
NRA (D)	2.43±0.51		2.45±0.58
PRA (D)	−2.59±0.69		−2.76±0.78
MEM (D)	0.92±0.31	0.93±0.21	0.75±0.37
AF (CPM)	8±5	9±5	10±2

AA: Amplitude of accommodation, NRA: Negative relative accommodation, PRA: Positive relative accommodation, MEM: Monocular estimate method, AF: Accommodative facility, SD: Standard deviation, CPM: Cycles per minute

Discussion

A discrepancy of greater than 1D between retinoscopy and subjective refraction is seldom seen clinically except as a result of an AS. In patients with a variant myopic presentation, AS was not responsible for this discrepancy as evidenced by an absence of key clinical presentations such as the presence of an esodeviation, a lead of accommodation, or a varying retinoscopy reflex.[4] The most convincing clinical evidence for the existence of VM is that the discrepancy between the techniques continued to persist under cycloplegia. In variant eyes, the mean ± SD of noncycloplegic subjective acceptance was −5.27 ± 1.76 D and cycloplegic subjective acceptance was −5.20 ± 1.78 D ($P > 0.05$)

In all participants with a variant myopic presentation, retinoscopy showed a mean ± SD difference of 1.87 ± 0.12 D compared to subjective acceptance, with subjective acceptance consistently being more myopic. Although retinoscopy is an objective procedure, it needs a subjective interpretation of the neutrality of the reflex, and there could be an argument that the examiners criteria to determine the end point had a hypermetropic bias.[6] However, the discrepancy between subjective acceptance and retinoscopy among controls was within the acceptable limits for clinical variability (mean difference ± SD: 0.40 ± 0.10 D and the ICC between the two examiners masked to the retinoscopy values showed good correlation for all participants). Retinoscopy has been considered as more accurate and reliable when performed by an experienced examiner,[9] and in the present study, the retinoscopy was performed by experienced examiners to minimize the role of examiner bias.

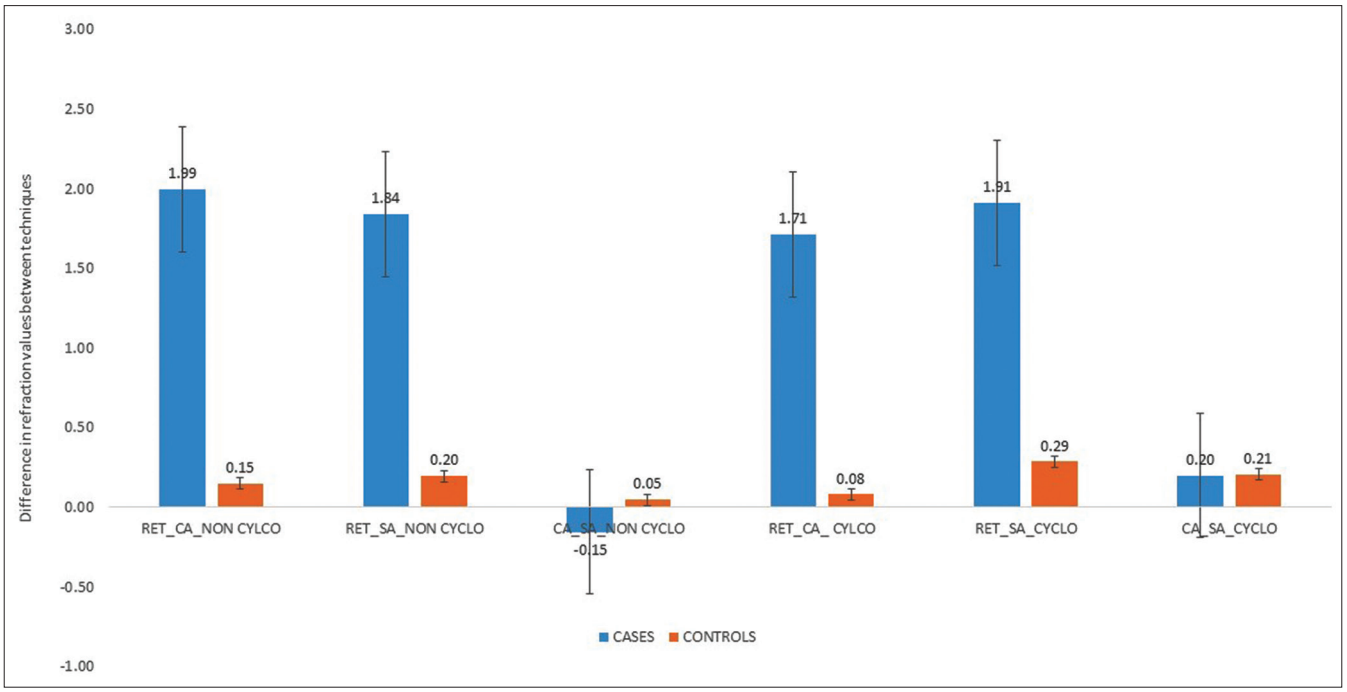

Figure 1: Difference in refraction estimates between techniques in cases and controls with and without cycloplegia. *RET: Retinoscopy, SA: Subjective acceptance, CA: Closed field autorefraction

Table 3: Noncycloplegic and cycloplegic refraction details of cases and controls

	Without cycloplegia				With cycloplegia			
	Cases (*n*=14)		Controls (*n*=14)		Cases (*n*=14)		Controls (*n*=14)	
	Mean±SD	Range	Mean±SD	Range	Mean±SD	Range	Mean±SD	Range
CA (D)	−5.42±1.87	−1.50–−8.29	−4.74±1.60	−1.62–−7.75	−5.00±1.79	−1.25–−7.91	−4.58±1.60	−1.46–−7.29
RET (D)	−3.43±1.62	0.00–−5.38	−4.59±1.51	−1.50–−7.00	−3.29±1.62	0–−5.50	−4.50±1.52	−1.50–−7.00
SA (D)	−5.27±1.76	−1.25–−7.50	−4.79±1.54	−1.50–−7.25	−5.20±1.78	−1.25–−7.50	−4.79±1.54	−1.50–−7.25

CA: Spherical value of closed field autorefraction, RET: Spherical value of retinoscopy, SA: Spherical value of subjective acceptance, SD: Standard deviation

Table 4: The dry closed field autorefractor, dry retinoscopy and dry subjective acceptance, axial length estimates of 14 individual variant participants

Partiicpants	CA (D)	RET (D)	SA (D)	AXL (mm)
1	−8.29	−5.38	−7.50	27.01
2	−7.54	−4.00	−7.00	26.19
3	−7.00	−5.00	−6.75	26.61
4	−6.08	−4.50	−6.50	27.38
5	−5.42	−4.25	−6.00	25.50
6	−6.75	−4.50	−6.00	24.37
7	−5.79	−4.25	−6.00	27.30
8	−5.33	−3.88	−5.00	25.41
9	−4.08	−2.63	−4.50	25.67
10	−3.87	−1.00	−4.00	25.46
11	−2.58	−1.25	−2.50	23.97
12	−1.50	0.00	−1.25	24.91
13	−6.00	−4.13	−6.00	24.15
14	−5.67	−3.25	−4.75	23.86

AXL: Axial length, CA: Spherical value of closed field autorefraction, RET: Spherical value of retinoscopy, SA: Spherical value of subjective acceptance

Table 5: Higher order aberrations in patients with variant myopic presentation, fellow eyes, and controls

Mean±SD of RMS of Zernike polynomials	Patients with variant myopic presentation	Fellow eyes of patients with variant myopia	Controls
Third order	0.23±0.12	0.24±0.10	0.23±0.17
Fourth order	0.17±0.15	0.14±0.03	0.12±0.09
Fifth order	0.08±0.04	0.07±0.04	0.05±0.02
Sixth order	0.05±0.02	0.04±0.01	0.03±0.01
Total HOA	0.53±0.25	0.43±0.25	0.49±0.16

HOA: Higher order aberrations, RMS: Root mean square, SD: Standard deviation

An anomalous with motion in retinoscopy due to pupil size, magnitude of myopia and working distance has been reported to misguide the examiner, due to the artifact of the edge of illuminated patch on the retina moving in the opposite direction to the light moving across the eye.[8] In our participants with variant myopic presentation, the discrepancy persisted under both dry and cycloplegic conditions and was not correlated with the magnitude of myopia. Hence, the effect of pupil size creating anomalous motion is unlikely to be a valid explanation.

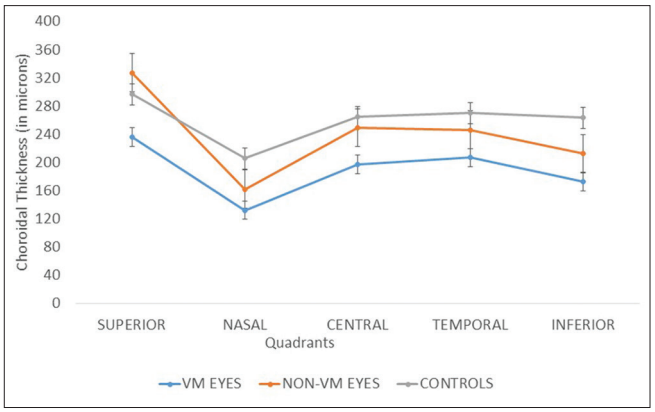

Figure 2: Comparison of choroidal thickness (mean ± spherical equivalent) between variant, nonvariant eyes of cases, and controls

Longitudinal chromatic aberration has been proposed as a potential source of hypermetropic bias within retinoscopy. The peak of the photopic luminosity function characterizes subjective refraction, whereas longer wavelengths characterize the origin of the retinoscopic reflex.[6] For humans, chromatic aberration has been shown to produce small discrepancies of a magnitude of up to 0.60D between retinoscopy and subjective acceptance[28] and thus cannot fully explain the discrepancies seen in the patients with a variant myopic presentation.

The next potential reason for inaccuracy could be off-axis retinoscopy, where small degrees of eccentricity can induce a significant spherical and cylindrical error.[14,30,31] The size of the area of the retina involved in neutralization is small and reported as approximately 1/640th the area of the optic disc, hence when performing retinoscopy on high myopes, even a small misalignment with the visual axis may induce spherical error in retinoscopic findings.[31,32] The effect of off-axis refraction was controlled in this study by (1) maintaining the same eye level between the examiner and the patient, (2) the trial frame was adjusted according to the interpupillary distance to avoid decentration, and (3) accurate centration of the reflex by aligning the streak across the vertical meridian of the patient. Furthermore, the best way to avoid transverse aberrations from influencing refraction is to neutralize the reflex across the largest visual zone and ignoring the reflex motion at the edges of the pupil.[33] This was consciously ensured in the present study during the refraction procedure.

All the participants with a variant myopic presentation had reduced accommodative facility values in both the eyes, though this was not statistically significantly different from the Indian clinical norms.[34,35] It is also well established in the literature that

the accommodative characteristics in Indian eyes are different, especially low among myopes.[29,36]

No statistically significant difference was observed between patients with variant myopic presentation and controls in the measured RMS of spherical aberrations and total HOA. HOAs have been shown to induce error up to 0.50D (range: 0.1–0.8D) during subjective refraction which increases with increase in higher order aberration.[10] Moreover, there is evidence that the effect of spherical aberration, the Stiles Crawford effect and induced spherical aberrations at the edges of pupil does not cause significant shifts in subjective acceptance under photopic conditions. This is attributed to the insensitivity of the visual system to spherical aberration under normal lighting conditions.[37]

Hung *et al*.[6] observed a large hypermetropic bias between objective and subjective refraction in monkeys and attributed this bias to a small eye artifact; the induced hypermetropic bias increased systematically as the axial length reduced.[13] In animal studies, this hypermetropic bias in retinoscopy ranged between +1.24D in monkeys[6] to +1.94D in rats.[7] In patients with variant myopic presentation, the retinoscopy value was on an average 1.87D more hypermetropic compared to the subjective acceptance.[6] It is noteworthy that there was a weak nonstatistically significant correlation between hypermetropic bias in retinoscopy and the measured axial length (Pearson's $r = 0.38$; $P > 0.05$) in our participants.

It is believed that conventional autorefractors overestimate myopia due to proximal accommodation, especially in children in noncycloplegic conditions.[38] But under cycloplegia, this difference should not exist. Patients with a variant myopic presentation in this study display the disparity in refractive error under both cycloplegic and noncycloplegic conditions. Could this difference be attributed to differences in wavelength used by the instruments? Retinoscopy uses visible light and autorefractors use near infrared light (NIR). NIR in autorefractors penetrates deeper than the reflex from retinoscopy light.[12] A significant amount of NIR reflected from the choroid can produce a myopic bias with autorefraction. It was reported that wavefront refraction with NIR is 0.25 D (range −0.56 D to +0.16 D) more myopic, on average, when compared to subjective refraction suggesting that the mean reflection layer is located 80–85 μm posterior to the entrance apertures of the photoreceptors.[12] Changing the reference wavelength by 20 nm is expected to cause a shift of 0.1 D in refraction.[11] The spectral distribution of the light source used in retinoscopy combined with the spectral distribution of light reflection from the retinal layer theoretically does not exceed a hypermetropic bias of 0.2D in subjective acceptance.[37] Nonetheless, treating the fundus layer as a single tissue is too simplistic as the reflex could arise from one of the many layers within the retina, choroid, and sclera.[12,38-40] The thinner choroids observed in the eyes presenting with VM (197.21 ± 13.04 μ) compared to their refractive error-matched controls (264.62 ± 12.53 μ) and emmetropes (276.21 ± 64.67 μ)[41] could be hypothesized to induce a hypermetropic bias but could the induced discrepancy be >1 D? It is important to point out that the emmetropic choroidal thickness values were taken from a previous study[41] as this study did not have emmetropic patients. Although fundus reflectance by different layers was reported to cause a discrepancy, larger discrepancies such as >1D as noted in the eyes presenting with VM have not been reported to date.[11,12,42]

There are certain limitations to our study. The anatomical and functional correlates documented in our study do not represent the full spectrum of possible etiologies responsible for this clinical finding. Depth of focus is one potential factor that could provide more insight and should be explored in the future work in this area. We also have no explanation for the unilateral presentation of this VM, and so this also needs further exploration.

As this is a case series of a rare presentation, we acknowledge that the sample size is low. However, the clinical importance of such presentation is what we would like to emphasize through this case series.

Conclusion

To the best of our knowledge, a discrepancy of >1D between objective and subjective measures both with and without cycloplegia has not been reported in human eyes. At this point, a clinician must be aware of such anomalous presentations and utilize an appropriate investigation and management strategy. Treating these cases as AS could lead to inappropriate management and patient dissatisfaction. Biometry measures and autorefraction estimates in such presentations could help in understanding the true or variant myopic nature of these cases. Therefore, these variant cases should be treated like true myopic cases with optimal minus powered lenses prescribed. The variant cases can be differentiated from accommodative cases by performing a proper cycloplegic refraction, testing accommodative parameters, and correlating the axial length value with the subjective refraction.

Acknowledgment

Peter Allen received a Collaborative Research Award from the College of Optometrists that facilitated his participation in this study. The authors also thank Ms. Aparna, Senior Optometrist, Sankara Nethralaya for her inputs and help with the aberration data.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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