Original Article

Evaluation of the vitreous chamber depth: An assessment of correlation with ocular biometrics

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Purpose: The mechanism of ocular growth eludes us and research on vitreous chamber depth (VCD) is lacking. The purpose of this study was to evaluate the role of VCD and its ratio to axial length (AL) in relation to ocular biometry. **Methods:** This retrospective study of patients planned for cataract surgery was performed at a tertiary center. Data regarding AL, anterior chamber depth (ACD), lens thickness (LT), and central corneal thickness (CCT) of 640 eyes was noted. Anterior segment (AS) was measured as sum of CCT, ACD, and LT, while VCD was calculated as the difference between AL and AS. Correlation of VCD and VCD: AL with ocular biometry was the primary outcome measure. Three groups were formed on the basis of AL and Pearson correlation coefficient (R) was applied. **Results:** Mean VCD was 15.38+/−1.14 mm. Mean VCD: AL was 0.66+/−0.02. VCD had a very strong relation with AL (R = 0.9, $P < 0.001$) only, whereas VCD: AL had a good--strong relation with AL (R = 0.5, $P < 0.001$), AS (R = 0.7, $P < 0.001$), ACD (R = 0.3, $P < 0.001$), and LT (R = 0.5, $P < 0.001$). The relation of VCD: AL with AS was very strong across all groups (R ≤ -0.8, $P < 0.001$ in all groups). 85% of eyes in group with AL <22 mm had VCD: AL <0.67, conversely 85% of eyes with AL >24.5 mm had VCD: AL >0.67. **Conclusion:** We found VCD to have the strongest relation with AL. VCD: AL was more consistent and showed a strong relation to ocular biometry across all ALs. This suggests the possible utility of the ratio VCD: AL while evaluating ocular growth, refractive status, and myopia-related complications.

Key words: Axial length, growth of eye ball, Myopia, ocular growth, vitreous chamber

Growth of the eye ball has fascinated ophthalmologists for a long time. Most of the research pertaining to it revolves around myopia and its management.[1] The size of the eye is known to depend on visual sensation. As the outer coats are the obvious end point of mechanism of ocular growth, it is very likely that the retina and the posterior segment have a very important role in determining the final biometry.[1-3] Choroidal changes responsible for ocular growth, including those of its ultra-structure and thickness, have been shown to depend on intense molecular signalling and vascular changes reliant on visual focus in experimental models.[1,4,5] This concept is behind formulation of multiple hypotheses for managing progressive myopia, including that of utilizing low dose topical atropine.[6-8]

The anterior structures may compensate for the optical effect of a longer eye ball by negating its component refractive error. A study of ocular component growth curves shows that myopia is more likely to be due to an alteration of growth, whereas emmetropia and hyperopia are a product of the initial size of the eye.[9] Since the anterior and the posterior segments of the eye have contrasting embryonic origins,[10] their growth may depend on different mechanisms. Yet, studies show the anterior segment to balance the posterior to nullify refractive error.[11] Hence, it is logical to ascertain a common factor which may influence the overall growth of the eye ball and its segments.

Current literature is lacking in terms of relationship between vitreous chamber depth (VCD) and rest of the ocular biometry. In a recent study of myopic eyes undergoing refractive surgery, we showed that there is a major discord between anterior biometry and the axial length (AL) of the eye ball.[12] We found the growth of the eye ball to be highly disproportionate, thus accounting for certain difficult scenarios surrounding refractive procedures. However, in that study we had noted an important limitation in our inability to evaluate VCD as a correlate of AL due to our sampling method.[12] In this study, we evaluate the relationship between VCD and other biometric parameters. We also introduce VCD: AL as a parameter that may influence overall ocular biometry, and thus provide clues to the refractive status or ocular growth.

Methods

This is a retrospective observational study evaluating records of patients planned for cataract surgery at a tertiary eye care centre

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of northern India. Part of this data has already been published regarding planning of a new intraocular lens library.[13]

Patients of age more than 40 years were included, while those with history of prior ocular procedures, congenital diseases, and trauma were excluded from the study. Cases where data was incomplete were also excluded. Biometric data inclusive of axial length (AL) in mm, anterior chamber

depth (ACD) in mm, lens thickness (LT) in mm, and central corneal thickness (CCT) in mm was noted. These parameters were measured using a single optical biometer (Lens Star, Haag-Streit, USA). All measurements were done by a single technician. AL was measured as the distance from the anterior corneal vertex to the internal limiting membrane (ILM) along the line of fixation. ACD was measured as the distance from the endothelial surface of cornea to anterior capsule of lens. CCT and LT were obtained by optical low coherence reflectometry. The anterior segment (AS) was measured as the sum of CCT, ACD, and LT; and the VCD was obtained as the difference between AL and AS. The VCD to AL ratio (VCD: AL) was measured using Microsoft excel sheets (Microsoft office 2007).

The primary outcome measures were correlation of ocular biometry with VCD and VCD: AL. Three groups were formed on the basis of AL, group 1 included eyes with AL <22 mm, group 2 included eyes with AL 22--24.5 mm, and group 3 included eyes with AL >24.5 mm. Variations between these 2 groups and correlation between rest of the variables were studied secondarily.

Data analysis was done using Stata statistical software version 12.0 (Stata Corp, College Station, TX, USA). Mean, range, and standard deviations were assessed for nonparametric variables and frequencies were calculated for parametric ones. Pearson correlation coefficient was applied to assess the primary outcome measures as both the variables were non-ordinal. A strong correlation was defined as $R > 0.5$ or $R < -0.5$, while very strong relation was defined as $R > 0.8$ or $R < -0.8$. Chi-square test was used to compare distribution of the 3 groups as a function of VCD: AL, while one way analysis of variance (ANOVA) test was used to compare group means as applicable. Only 2-tailed P values <0.05 were taken to be statistically significant.

Results

Records of 850 eyes were initially screened. 640 eyes were found to meet the selection criteria. The mean age of patients was 60.3+/−8.9 years and 70% were male. Right and left eyes were nearly equal in number (50% each). Mean AL, CCT, LT, ACD,

Table 1: Distribution of variables

Parametric	Frequency (*n*)	Percentage (%)
Eye		
Right	318	49.7
Left	322	50.3
Gender		
Male	449	70.2
Female	191	20.8
Groups based on AL		
Group 1 (<22 mm)	65	10.2
Group 2 (22-24.5 mm)	512	80.0
Group 3 (>24.5 mm)	63	9.8
Groups based on VCD: AL		
Group A (<0.67)	372	58.1
Group B (≥0.67)	268	41.9

Non parametric				
	Minimum	Maximum	Mean	SD
Age	40.00	83.00	60.30	8.99
AL	19.40	29.52	23.23	1.14
CCT	0.39	0.62	0.52	0.04
LT	3.04	5.89	4.30	0.41
ACD	2.02	4.71	3.04	0.44
AS	5.85	9.21	7.85	0.45
VCD	11.07	21.73	15.38	1.14
VCD: AL	0.56	0.74	0.66	0.02

All numerical values are in mm unless indicated. SD=Standard deviation, AS=Anterior segment, AL=Axial length, CCT=Central corneal thickness, LT=Lens thickness, ACD=Anterior chamber depth, VCD=Vitreous chamber depth

Table 2: Correlation between all parameters

		AL	CCT	LT	ACD	AS	VCD	VCD: AL
AL	Correlation coefficient	1	0.131	-0.154	0.325	0.188	**0.921**	**0.544**
	P		0.001	0.000	0.000	0.000	0.000	0.000
CCT	Correlation coefficient	0.131	1	-0.062	0.109	0.129	0.079	-0.022
	P	0.001		0.117	0.006	0.001	0.046	0.571
LT	Correlation coefficient	-0.154	-0.062	1	-0.450	0.469	-0.339	**-0.501**
	P	0.000	0.117		0.000	0.000	0.000	0.000
ACD	Correlation coefficient	0.325	0.109	-0.450	1	**0.575**	0.096	-0.265
	P	0.000	0.006	0.000		0.000	0.015	0.000
AS	Correlation coefficient	0.188	0.129	0.469	**0.575**	1	-0.210	**-0.718**
	P	0.000	0.001	0.000	0.000		0.000	0.000
VCD	Correlation coefficient	**0.921**	0.079	-0.339	0.096	-0.210	1	**0.827**
	P	0.000	0.046	0.000	0.015	0.000		0.000
VCD: AL	Correlation coefficient	**0.544**	-0.022	**-0.501**	-0.265	**-0.718**	**0.827**	1
	P	0.000	0.571	0.000	0.000	0.000	0.000	

AS=Anterior segment, AL=Axial length, CCT=Central corneal thickness, LT=Lens thickness, ACD=Anterior chamber depth, VCD=Vitreous chamber depth

AS, VCD, and VCD: AL were found to be23.23+/− 1.14 mm, 0.52+/−0.04 mm, 4.30+/− 0.41 mm, 3.04+/− 0.44, 7.85+/− 0.45 mm, 15.38+/− 1.14 mm, and 0.66+/− 0.02, respectively. Nearly 10% of eyes were distributed in groups 1 and 3, while 80% were in group 2. This data and distribution of variables has been summarized in Table 1.

Correlation analysis was performed between biometric variables and has been summarized in Table 2. VCD: AL was found to have a good--strong relation with all the variables, apart from CCT. VCD showed a very strong correlation with AL ($R = 0.921$, $P < 0.001$), but not with any other variable. Among the anterior parameters, a strong relation was observed only between AS and ACD ($R = 0.575$, $P < 0.001$). CCT correlated poorly with all variables. No other anterior parameter showed a strong correlation. Thus, although VCD correlated best with AL, VCD: AL had the most consistent correlation with ocular biometry.

Groups 1, 2, and 3 were compared for variation of VCD: AL [Table 3]. The mean value of VCD: AL (0.66) was chosen to divide VCD: AL in 2 groups. Although nearly 85% of the group 1 eyes had VCD: AL <0.67, nearly 85% of the group 3 eyes had VCD: AL > 0.67. This difference was found to have very high statistical significance ($P < 0.001$). Hence, VCD was seen to occupy a greater part of the eye length as the AL increased.

The 3 groups formed on the basis of AL were then evaluated individually for correlation between AS, VCD, VCD: AL, and AL. VCD: AL was again found to be the most consistent variable. It exhibited very strong correlation with AS in all the groups, in comparison to VCD which showed moderate to strong correlations [Table 4]. However, VCD individually showed a stronger correlation with AL than VCD: AL in all the 3 groups. This was consolidated by the finding of VCD

having the highest F statistic on application of ANOVA to determine differences in AS, VCD, and VCD: AL between the 3 groups [Table 5]. AL showed a very weak relation with AS in all the groups [Table 4].

AS: VCD was analyzed for its correlation with ocular biometry, just like VCD: AL. Surprisingly, the pattern of correlation exhibited by AS: VCD was completely identical to that of VCD: AL [Table 6]. Furthermore, there was an excellent correlation between AS: VCD and VCD: AL ($R = −0.988$, $P < 0.001$).

Discussion

The literature lacks in respect to VCD, and our study provides several new insights in this regard, apart from setting a normative Indian database. We have provided an extensive analysis for variation of VCD with ocular biometry, and have evaluated VCD: AL as its correlate. We found that VCD is a better correlate of AL than AS, or any sub-parameter of AS. Furthermore, we showed that VCD: AL has the most consistent relationship with ocular biometrics. As a secondary analysis, we also proved that VCD occupies greater parts of the eye with increasing AL and that VCD: AL correlates best with AS, even better than ACD or LT. However, the most intriguing result is the similarity between VCD: AL and AS: VCD.

Ocular biometry has been studied comprehensively in all areas of the world. However, VCD has been scarcely studied. Table 7 presents the summary of the available studies.[14-23] The mean VCD detected by our study falls well within the range measured by these studies. It can be easily noted that most of these studies are population based, rather than the current study which is hospital based. While in general hospital-based studies have inherent biases, they may have better exclusion criteria as hospital-based ocular examination is better focussed in ruling out ocular morbidities. Some work has also been done in the context of progressively increasing VCD in myopia as presented in Table 7.[23]

It is known that patterns of development or regression of embryonic primary vitreous can influence the size of the eye and its AL.[24] This is one of the reasons due to which eyes with persistent fetal vasculature have a high chance of having microphthalmia.[24-26] Hence, a very strong relation between VCD and AL is expected. The second reason for the same is the biomechanical nature of the vitreous that allows it to stretch as

Table 3: Distribution of VCD: AL as a function of AL

	VCD:AL		Total
	<0.67	≥0.67	
AL			
<22 mm	55	10	65
22-24.5 mm	307	205	512
>24.5 mm	10	53	63
Total	372	268	640

Table 4: Correlation between variables in groups based on AL

		Group 1 (AL <22 mm)			Group 2 (AL 22-24.5 mm)			Group 3 (AL >24.5 mm)		
		AS	VCD	VCD:AL	AS	VCD	VCD:AL	AS	VCD	VCD:AL
AL	Correlation coefficient	-0.078	**0.840**	**0.530**	0.154	**0.783**	0.307	-0.174	**0.937**	**0.675**
	P	0.539	0.000	0.000	0.000	0.000	0.000	0.172	0.000	0.000
AS	Correlation coefficient	1	**-0.606**	**-0.886**	1	-0.495	**-0.893**	1	**-0.506**	**-0.843**
	P		0.000	0.000		0.000	0.000		0.000	0.000
VCD	Correlation coefficient	**-0.606**	1	**0.904**	-0.495	1	**0.833**	**-0.506**	1	**0.890**
	P	0.000		0.000	0.000		0.000	0.000		0.000
VCD:AL	Correlation coefficient	**-0.886**	**0.904**	1	**-0.893**	**0.833**	1	**-0.843**	**0.890**	1
	P	0.000	0.000		0.000	0.000		0.000	0.000	

AS=Anterior segment, AL=Axial length, VCD=Vitreous chamber depth

Table 5: Comparison of means between groups

Groups based on AL		VCD	VCD:AL	AS
1.00	Mean	13.75	0.64	−7.62
	Std. Deviation	0.81	0.02	−0.44
2.00	Mean	15.33	0.66	−7.86
	Std. Deviation	0.71	0.02	−0.45
3.00	Mean	17.45	0.69	−7.98
	Std. Deviation	1.20	0.02	−0.43
P		<0.001	<0.001	<0.001
F statistic		360.59	67.17	11.65

AL=Axial length, VCD=Vitreous chamber depth, AS=Anterior segment

Table 6: Consistency of factors for relation ocular biometry

		AS:VCD	VCD:AL
AL	Correlation coefficient	**−0.543**	**0.544**
	P	0.000	0.000
CCT	Correlation coefficient	0.027	−0.022
	P	0.491	0.571
LT	Correlation coefficient	0.486	**−0.501**
	P	0.000	0.000
ACD	Correlation coefficient	0.270	−0.265
	P	0.000	0.000
AS	Correlation coefficient	**0.710**	**−0.718**
	P	0.000	0.000
VCD	Correlation coefficient	**−0.822**	**0.827**
	P	0.000	0.000

AS=Anterior segment, AL=Axial length, CCT=Central corneal thickness, LT=Lens thickness, ACD=Anterior chamber depth, VCD=Vitreous chamber depth, The correlation between AS=VCD and VCD=AL was found to be -0.988 (P=0.000)

compared with the AS which is relatively stiff. A longer eye ball thus is expected to have a higher proportion of VCD which can be appreciated by a higher VCD: AL in group 3 in our study.

The consistent relation of VCD: AL with ocular biometry is intriguing [Table 2], as is its similarity with AS: VCD [Table 6]. In fact, VCD: AL proved to have a stronger relation with AS than ACD or LT [Table 2]. We had noted a similar lack of correlation between anterior parameters in myopic patients in a previous study.[12] One may speculate these findings to have a simple mathematical explanation, that is, both AS and VCD contribute to AL. Hence, ratio of either of them to AL may have good relation to both. However, in such a situation, the individual correlation coefficient of AS and VCD to AL should also have been similar, which is not the case [Table 2]. The reasons for our findings are not clear at the moment, but the authors are of the view that VCD: AL may be a useful marker of ocular growth or refractive status, and should be studied further. Although relation between corneal curvature and AL has been studied prior,[11] VCD: AL has not been studied before. Future studies can evaluate patterns of VCD: AL during early childhood, as also during progressive phase of pathological myopia. In the latter population, VCD: AL may also be a prognostic indicator of retinal complications by indicating vitreous stretch. Meng *et al.* concluded in a comprehensive review on AL regarding the requirement of "new creative studies" on myopia and its determinants.[27] VCD: AL seems to be a promising answer in this context in view of its consistent nature.

Limitations: Apart from its retrospective nature, there are 2 main limitations of this study. Firstly, all patients had cataract which in effect alters LT and therefore may have an effect on the VCD too. Inclusion of patients of all ages could have nullified this limitation to some extent. Secondly, there were 63 patients in group 3. At least 11 of them had posterior staphyloma clinically and/or on ultrasound. Due to retrospective nature of this study, we cannot ascertain the exact number or provide a

Table 7: Comparison with literature

Study	Place, year	Sample	Method	Mean VCD	Remark
Current study	2018, North-central India	640	Optical	15.38	Very strong relation with AL (R=0.92), VCD: AL showed better relation with biometry, Hospital based
Ray *et al.*[14]*	2011, East India	40	USG	15.42	Relation between AL and VCD not provided, Hospital based
Hashemi *et al.*[15]	2009, Iran	4823	optical	15.72	Study focusses on age based changes, population based study, relation between AL and VCD not provided
Wickremasinghe *et al.*[16]**	2004, Mongolia	1313	USG	>16.0	Study focusses on age/refraction based changes, population based study, relation with AL not provided
Wong *et al.*[17]	2001, Singapore	1232	USG	15.58	Study focusses on age/refraction based changes, population based study, relation with AL not provided
Warrier *et al.*[18]	2015, Myanmar	2076	USG	15.43	Study focusses on age/refraction based changes, population based study, weak exclusion criteria, relation with AL not provided
Mallen *et al.*[19]	2005, Jordan	1093	USG	16.04	Study focusses on gender/refraction based changes, population based, relation with AL not provided
Shufelt *et al.*[20]	2005, USA (Latinos)	5588	USG	15.04	Study focusses on gender/refraction based changes, population based, relation with AL not provided
Niu *et al.*[21]***	2016, China	6483	USG	15.28-15.73	Study focusses on gender/refraction based changes, population based, relation with AL not provided
Saka *et al.*[22]****	2010, Japan	1568	USG	21-22.3	Only high myopes included

USG=Ultrasound, AL=Axial length, VCD=Vitreous chamber depth. *Study has total sample of 152, but over all mean not provided **Study does not provide overall mean. ***Study is multiethnic and mean results not provided ****Study done for progression of myopia in high muopes over at least 5 years

subgroup analysis. It is theoretically possible that this fallacy may have affected measurement of VCD in these patients.[26,28] However, the consistent nature of all parameters across all groups indicates otherwise [Table 4].

Conclusion

VCD has a very good correlation with AL of the eye, while VCD: AL has a very consistent and strong relation with ocular biometry inclusive of the anterior segment parameters. In comparison to a normal or a shorter eye, larger proportion of a myopic eye ball is occupied by the vireous chamber. VCD: AL should be studied further in prospective models for its relation with ocular growth and retinal complications in myopia.

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Conflicts of interest

There are no conflicts of interest.

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