Assessing retinal and choroidal thickness changes in vitreomacular traction syndrome using enhanced depth imaging optical coherence tomography.

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Abstract

Aim: To evaluate effect of different types and stages of Vitreomacular Traction (VMT) on morphology of retina and choroid using spectral domain optical coherence tomography (SD-OCT) utilizing Enhanced Depth Imaging (EDI).

Methods: Observational cross sectional analytic study. Conventional SD-OCT scans were analyzed to measure Central Foveal Thickness (CFT), Vitreomacular Adhesion (VMA) area and grade, VMT Angle (VMTA) and posterior hyaloid thickness. EDI scans were analyzed to measure choroidal thickness. Main outcome measures: Average choroidal thickness, comparing mean CFT and average choroidal thickness between different VMT groups and grades, and correlating each of mean CFT and average choroidal thickness on one hand and average VMTA, VMA area and posterior hyaloid thickness on the other.

Results: The study included 104 eyes (104 patients). There was statistically significant difference in CFT between concurrent vs. isolated VMT. Choroidal thickness was significantly higher in concurrent compared to isolated VMT. There was correlation between VMTA and CFT, where wider angle was associated with increased CFT. Broader VMA was associated with increased choroidal thickness.

Conclusion: VMT independent of macula and fovea, influences choroidal structure. Angle of vitreous adhesion is important in determining changes at vitreoretinal interface. These observations need to be further investigated in prospective longitudinal studies.

Keywords: Choroidal thickness, Enhanced depth imaging, Spectral domain optical coherence tomography, Vitreomacular traction.

Introduction

Attachment of posterior hyaloid to foveal center with detached vitreous around macula is known as vitreomacular adhesion (VMA). With further separation of vitreous and steep sloping of inner macular surface, it may progress to vitreomacular traction (VMT). [1]. The International VMT Classification Study Group classified VMT according to type and severity of pathology. VMT types are: A) Focal (<1500 um), B) Broad (>150 um), C) Isolated (not associated with other disorders), and D) Concurrent [associated with other disorders; Full Thickness Macular Hole (FTMH), epiretinal membrane (ERM), age related macular degeneration (AMD)]. VMT Severity is graded into: Grade 1 (VMA plus elevated inner retinal surface), Grade 2 (Grade 1 plus intra retinal cysts or clefts), and Grade 3 Grade 2 plus Sub Retinal Fluid (SRF) [2].

Only one study by Kozak et al. assessed effect of VMT on Central Foveal Thickness (CFT), central subfoveal, and adjacent choroidal thickness. They showed that central and paracentral choroidal thickness are increased in broad VMT, in which forces are less effective in achieving focal detachment, but may result in stretching the choroid. However, wider (more open) angle, leading to V-shape VMT, was not associated with increased choroidal thickness, but with increased CFT, resulting in faster VMT resolution and possibly Tractional Cystoid Macular Edema (TCME) and MH formation [3]. In this study we evaluated the effect of different types and stages of VMT on morphology of retina and choroid using Spectral Domain Optical Coherence Tomography (SD-OCT) and utilizing image averaging and Enhanced Depth Imaging (EDI).

Materials and Methods

This is an observational cross sectional analytic study of patients with VMT where macular SD-OCT B Scans and EDI (RTVue Fourier-Domain OCT, v 6.11.0.12, Optovue Inc., USA) were conducted and measurements of vitreoretinal interface images were analyzed and recorded. The study was conducted at Kasr Al-Ainy University Hospital in accordance with Declaration of Helsinki and with applicable institutional research regulations. All patients received complete explanation of study design and aims. Study participants gave informed consent before initiation of any procedures. The protocol was revised and approved by Ophthalmology Department ethical committee.

Patient selection

Inclusion criteria: Patients with VMT syndrome, isolated or concurrent (focal or broad), with various grades of severity.

Exclusion criteria: History of ocular surgeries, myopic traction maculopathy [schisis-like retinal thickening in high myopia with Spherical Equivalent (SE) >-6.0D or axial length >26.0 mm and posterior staphyloma], hypermetropia >+3D, media opacities obscuring imaging, or history of laser treatment.

All participants were subjected to complete ophthalmological examination

Including Best Corrected Visual Acuity (BCVA) in log MAR and refraction, slit lamp examination, intraocular pressure (IOP) with Goldmann applanation tonometry, dilated fundus examination by binocular indirect slit-lamp bio microscopy and indirect ophthalmoscope, examination of fellow eye, and axial length using A-scan ultrasound.

Diagnosis of VMT in all patients was confirmed using SD-OCT

OCT imaging was performed with conventional and EDI cross-sectional scans with excitation wavelength 870 nm and scanning speed 40,000 A-scans/second. Axial resolution is ~6 µ, compared to lateral resolution of 14 µ. EDI was performed by positioning SD-OCT closer to eye to generate inverted image on top of computer display. A possible physical explanation for EDI may be decreased delay in light wavelengths returning from depicted sub retinal structures that are further away from zero delay line; this was detected by interferometer and compared to light wavelengths of reference arm, final result of which was better signal intensity of imaged deeper layers. Horizontal and vertical OCT images were obtained through fovea, each comprised of 15 averaged scans. Acquisition of cross-sectional scans was obtained together with infrared, real-time fundus image, which allowed point-to-point correlation between fundus images and OCT cross-sectional scans. Same modality with a horizontal and vertical cross-sectional scan was used to obtain conventional scans for comparison.

Conventional scans were used for

- CFT (mean thickness of central 500 µm radius area using 6 radial scans).
- VMT area: Classified based on International VMT Study Group Classification into focal and broad. Based on severity of VMT eyes were graded into grades 1-3 [2].
- VMT angle (VMTA): measured as angle between Retinal Pigment Epithelium (RPE) and posterior hyaloid, at fovea. Nasal, temporal, superior and inferior angles were measured, and then average of these 4 measurements was calculated.
- Posterior hyaloid thickness.

EDI scans were used for: Choroidal thickness was measured at 9 points; sub foveal region, parafoveal region 500 µ from fovea center in both horizontal and vertical planes (superior, inferior, nasal and temporal quadrants) and 2500 µ from fovea center in both horizontal and vertical planes (superior, inferior, nasal and temporal quadrants).

Outcome measures

- Comparing mean choroidal thicknesses at each of measured 9 points. Then these 9 points were averaged to only one point; average choroidal thickness.
- Comparing average choroidal thickness between eyes with VMT and normal other eye of patients with isolated VMT.
- Comparing mean CFT and average choroidal thickness between each of: a) Focal and broad, b) Isolated and concurrent, and C) The three VMT grades
- Correlating each of mean CFT and average choroidal thickness and the following: A) Average VMTA, B) VMA area, C) Posterior hyaloid thickness
- Correlating average choroidal thickness and BCVA in LogMAR

Statistical analysis

Data were statistically described in terms of range, mean ± standard deviation (± SD), median frequencies (number of cases) and percentages when appropriate. Comparisons were done using Mann Whitney, and Wilcoxon Signed Rank tests for nonparametric data. Correlation between various variables was done using Spearman's rank equation. Risk factors affecting CFT and average choroidal thickness were studied using multiple linear regressions. For comparing categorical data, Chi square (χ2) test was performed. All p values <0.05 were considered statistically significant. Statistical calculations were done using computer programs Microsoft Excel 2007 (Microsoft Corporation, NY, USA) and SPSS (Statistical Package for Social Science; SPSS Inc., Chicago, IL, USA) version 18.

Sample size for a quantitative cross sectional study was calculated using computer programs according to formula: Z1-α/22 SD2/d2, where SD is standard deviation (51 µm) taken from previous studies. Z1-α/2 is standard normal variate for level of significance (α=0.05; Z0.05 =1.82), and d is absolute error (d=15 µm). Sample Size: N=(1.82 x 51)2 /152=8615.5524/225=38.3. Power of study=0.8.

Results

This study was conducted from April 2016 to November 2017 at Kasr Al Ainy hospital. It included 104 eyes of 104 patients divided into 3 groups: Isolated: 40 eyes (40 patients). Concurrent: 40 eyes (40 patients), 32 of which associated with diabetic retinopathy (DR) (80%) and 8 with age related macular degeneration (AMD) (20%). VMT associated with idiopathic FTMH: 24 eyes of 24 patients.

Demographic data

Patients' mean ages were 49.5 ± 4.1 (42-56), 53.5 ± 4.2 (40-58), and 48.5 ± (4.34-56) years (p<0.001), with 21 (52.5%), 21 (52.5%), and 9 (37.5%) males (p=0.456) for isolated, concurrent, and FTMH respectively.

Patients' ocular features

Patients' BCVA, SE, axial length and IOP were recorded in each group, with statistically significant difference between 3 groups regarding BCVA (p<0.001) (Tables 1 and 2).

Table 1. *Best Corrected VIsual Acuity (BCVA), spherical equivalent (SE), axial length and intraocular pressure (IOP) in each of the 3 groups.*

	Isolated				**Concurrent**				**FTMH**				P value
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	
BCVA (Decimal)	0.5	0.1	0.3	0.8	0.3	0.2	0.1	0.8	0.1	0.04	0.05	0.2	<0.001
SE (Diopters)	-0.3	1.6	-2.5	2.3	-0.2	1.5	-2.5	2.5	-0.1	1.7	-2.5	2.5	0.771
Axial Length (mm)	23	0.5	22	24	23	0.7	22	24.3	23.1	0.6	22	24.4	0.781
IOP (mmHg)	14	1.5	12	16	13.8	1.6	11	16	13.5	1.5	12	16	0.398
Note: P value < 0.05 is considered statistically significant													

Table 2. *Conventional SD-OCT scans for CFT, VMT horizontal, vertical and average diameters, VMTA and posterior hyaloid thickness; and EDI OCT scans for choroidal thickness in different zones.*

			Isolated				**Concurrent**				**FTMH**				P value
			Mean	**SD**	**Min**	**Max**	**Mean**	**SD**	**Min**	**Max**	**Mean**	**SD**	**Min**	**Max**	
CFT (μ)			152.1	12	128	169	389.1	139	189	607	-------	-----	-------	------	<0.001
VMT Diameter (μ)		Vertical	1180.9	813.3	210	2600	1133.5	757.2	280	2200	-------	-----	-------	------	0.776
		Horizontal	1182.2	812.4	210	2600	1133.5	757.2	280	2200	-------	-----	-------	------	0.772
Average VMA Area (μ)			1181.6	812.8	210	2600	1133.5	757.2	280	2200	-------	-----	-------	------	0.772
VMT Angle (°)		Nasal	17.6	7.9	15	50	34.6	13.7	15	70	25	5.9	15	40	0.001
		Superior	28.1	8.2	15	50	34.9	13.3	15	70	26.3	6.1	15	40	0.006
		Temporal	27.5	7.8	15	50	34.4	13	15	70	26.3	5.8	15	40	0.006
		Inferior	27.5	7.8	15	50	34.4	13.1	15	70	25	5.5	15	35	0.002
		Average	27.7	7.8	15	50	34.6	13.1	15	70	25.6	5.2	15	35	0.003
Posterior Hyaloid Thickness (μ)		Vertical	30.7	3.9	25	36	31.1	4.1	25	38	32.8	5.1	25	42	0.258
		Horizontal	31.2	4.5	25	38	31.6	4.4	25	40	33.9	5.3	27	44	0.114
		Average	30.9	3.9	25	37	31.3	4.1	25	38	33.3	5	27	43	0.207
Choroidal Thickness (μ)	Subfoveal	Horizontal	164.7	12.7	145	197	170.1	14.5	145	201	159.5	9.7	143	182	0.018
		Vertical	165.5	13.1	141	201	170.1	14.5	145	201	159.2	9.3	143	180	0.013
		Average	165.1	12.8	143	199	170.1	14.4	145	201	159.4	9.5	144	181	0.021
	At 500 μ	Superior	165.3	12.4	142	192	170.4	13.7	142	198	157.5	11.6	142	179	0.001
		Inferior	166.5	11	150	191	171.1	13.3	150	199	159.3	8.6	150	178	0.001
		Nasal	167.7	9.7	153	195	172	12	154	202	160.5	7	152	176	<0.001
		Temporal	167.3	11.9	151	199	171.4	13.6	151	200	160	8.8	151	178	0.002
	At 2500 μ	Superior	164.8	11.7	143	190	170.2	13.3	143	198	157.2	10.7	143	175	0.001
		Inferior	166.4	9.1	153	192	170.9	12.4	153	201	161.3	7.1	153	173	0.003
		Nasal	168.2	10.7	152	194	172.7	12.3	152	204	160.5	8.4	153	178	0.001
		Temporal	167.5	10.9	151	204	172.4	12.1	151	204	161.6	8.2	151	176	<0.001

SD-OCT imaging data analysis/Conventional scans were used for measuring

CFT: Significant difference between isolated and concurrent VMT (p<0.001).

VMA area: Vertical, horizontal and average VMT diameters were measured in isolated and concurrent groups, with no significant difference.

VMA area was classified into focal [20 eyes (50%) in each of isolated and concurrent groups] and broad [20 eyes (50%) in each of isolated and concurrent groups] with no significant difference between both groups (p=1.00).

VMTA: Measurements were significantly different between 3 groups. It was also compared between focal and broad VMT and between different grades of VMT, in each of 3 groups, with no statistically significant difference.

Posterior hyaloid thickness: was measured in vertical and horizontal scans and average thickness was calculated, in each group with no significant difference between them. It was also compared, in each group, between focal and broad, with statistically significantly difference in concurrent VMT (p=0.036, p=0.010 and p=0.014, for vertical, horizontal and average scans, respectively) and between different grades, with significant difference in FTMH group (p=0.004, for each of vertical, horizontal and average scans). Based on severity of VMT, eyes were graded in each group into grades 1-3, with statistically significant difference between them (p<0.001) (Table 3).

Table 3. *Distribution of various grades of VMT in the each of the 3 groups.*

VMT Grade		Isolated	Concurrent	FTMH
Grade 1 (Mild)	Count	8	8	12
	%	20.00%	20.00%	50.00%
Grade 2 (Moderate)	Count	17	17	0
	%	42.50%	42.50%	0.00%
Grade 3 (Severe)	Count	15	15	12
	%	37.50%	37.50%	50.00%

EDI scans were used for measuring

Choroidal thickness: There was a statistically significant difference between 3 groups at each of measured zones (Table 2).

Average choroidal thickness

- Comparing choroidal thickness between these 9 zones in each group showed no statistically significant difference: (p=0.919, p=0.994 and p=0.749, in isolated, concurrent and FTMH, respectively)
- So, these 9 zones were averaged to get average choroidal thickness in each group: 166.5 ± 10.8 µ (150.3-195.1 µ), 171.2 ± 12.8 µ (150.4-199.1 µ), 159.7 ± 8.5 µ (150.2-177.1 µ), and 165.5 ± 9.8 µ (151-187 µ), in isolated, concurrent, FTMH and normal control, respectively.
- Comparing average choroidal thickness between eyes with VMT and normal other eye of patients with isolated VMT: Statistically significant in FTMH (p=0.017), but not in isolated and concurrent (p=0.651 and p=0.051, respectively).
- Comparing mean CFT and average choroidal thickness between each of:

Isolated, concurrent VMT and FTMH: Statistically significant difference, in each of CFT and average choroidal thickness (p<0.001 each).

Focal and broad VMT: Isolated: No statistically significant difference, in each of CFT and average choroidal thickness (p=0.083 and p=0.250, respectively).

Concurrent: No statistically significant difference, in each of CFT and average choroidal thickness (p=0.432 and p=0.408, respectively).

The three VMT grades: Isolated: No statistically significant difference, in each of CFT and average choroidal thickness (p=0.855 and p=0.589, respectively).

Concurrent: No statistically significant difference, in each of CFT and average choroidal thickness (p=0.178 and p=0.190, respectively).

FTMH: No statistically significant difference in average choroidal thickness between 3 grades (p=0.155) Correlations.

Correlating each of mean CFT and average choroidal thickness and the following using Spearman's Rank correlation

Average VMTA

Isolated: No significant correlation with each of CFT and average choroidal thickness [(p=0.977, r=0.005) and (p=0.267, r=-0.180), respectively].

Concurrent: Moderately strong direct significant correlation with each of CFT and average choroidal thickness [(p=0.030, r=0.335) and (p=0.010, r=0.403), respectively].

FTMH: No significant correlation with choroidal thickness (p=0.982, r=0.005).

Diameter of VMA area

Isolated: No significant correlation with each of CFT and average choroidal thickness [(p=0.260, r=0.182) and (p=0.254, r=-0.185), respectively].

Concurrent: No significant correlation with each of CFT and average choroidal thickness [(p=0.703, r=-0.062) and (p=0.984, r=-0.003), respectively].

Posterior hyaloid thickness

Isolated: CFT: No significant correlation (p=0.166, r=0.224). Average choroidal thickness: Inverse moderately strong significant correlation (p=0.003, r=-0.457).

Concurrent: No significant correlation with each of CFT and average choroidal thickness [(p=0.602, r=-0.085) and (p=0.123, r=-0.248), respectively].

FTMH: Direct moderately strong significant correlation with average choroidal thickness (p=0.036, r=0.429).

Correlating BCVA to CFT and average choroidal thickness

Isolated: CFT: No significant correlation (p=0.802, r=-0.041). Average choroidal thickness: Inverse moderately strong significant correlation (p=0.025, r=-0.355).

Concurrent: CFT: Inverse moderately strong significant correlation (p=0.004, r=-0.440). Average choroidal thickness: No significant correlation (p=0.971, r=-0.006).

FTMH: No significant correlation with choroidal thickness (p=0.581, r=0.119).

Correlating CFT to average choroidal thickness

Isolated: No significant correlation (p=0.392, r=-0.158).

Concurrent: No significant correlation (p=0.074, r=0.285).

Factors affecting CFT and Average choroidal thickness were studied using multilinear regression

CFT: Association with DR/AMD was significant (p<0.001), while age, sex, BCVA, SE, axial length and IOP were not.

Average choroidal thickness: BCVA was significant (0.043), while age, sex, SE, axial length, IOP and association with DR/AMD were not.

Discussion

Twelve studies, over the past decade (2008-2018) as mentioned in Medline, used SD-OCT to study both structure and classification of VMT, or its natural course [3-14] of these 12; 4 were prospective studying natural course of VMT, [11-14] and 8 were retrospective; [3-10] 4 of which studied structure and classification of VMT [3-6] and the other 4 studied its natural course [7-10]. None of the 4 prospective studies measured choroidal thickness or posterior hyaloid thickness and their relationship with VMT. On the other hand 3 of them measured VMA area [12-14], 2 of which measured CFT and VMTA [12,13]. Also out of the 8 retrospective studies, none of them measured choroidal thickness, posterior hyaloid thickness or VMTA and their relationship with VMT except for Kozak, et al. [3]. Also none of them has measured VMA area except three studies [3,7,10]. Only 2 studies have not studied CFT [8,9].

Conventional SD-OCT images

CFT: We had significant difference between isolated and concurrent groups ($p<0.001$). In a study by Errera, et al. presenting base line CFT in focal group was statistically significantly less than that of broad ($p<0.001$), while, Kozak, et al. had no statistically significant difference between focal vs. broad and between isolated vs. concurrent VMT [3,7]. Other researchers also found various results regarding CFT [7]. Others have not measured CFT [4-6,8-10,12-14].

VMA area: Comparing isolated and concurrent groups together in vertical, horizontal and average scans showed no statistical significant difference between them. Other studies have also measured VMA diameter [3,7,12-14]. Codenotti, et al. measured the mean value of VMA area and not diameter [10].

VMTA: In our study, there was statistically significant difference between 3 groups regarding nasal, temporal, superior, inferior and average VMTA. Three studies have measured VMTA and its relation to VMT. But unlike our study, they measured only nasal and temporal VMTA [3,12,13].

Posterior hyaloid thickness: In our study, 3 groups were compared together with no statistically significant difference. None of afore mentioned studies measured posterior hyaloid thickness except for Kozak, et al. [3] who correlated it to choroidal thickness.

Severity of VMT: This study included 28 patients with mild type, where 8 (28.6%) had isolated VMT, 8 (28.6%) had concurrent and 12 (42.9%) had FTMH; 34 patients with moderate VMT, where 17 (50%) had isolated, 17 (50%) had concurrent; and 42 had severe VMT, where 15 (35.7%) had isolated, 15 (35.7%) had concurrent and 12 (28.6%) had FTMH. Similar to our work, John, et al. and Kozak, et al. also classified VMT to mild, moderate and severe types [3,11]. Others have studied natural course of VMT grouping cases into eyes with spontaneous separation and others with persistent VMT with its various effects [7-10,12,13].

EDI OCT, choroidal thickness: In the current study, we compared average choroidal thickness between eyes with VMT and normal other eye of patients with isolated VMT with no significant difference. None of studies measured choroidal thickness except for Kozak, et al., who in contrast to ours, only measured subfoveal, nasal and temporal thickness at 500 μ [3].

Comparing CFT and average choroidal thickness between each of the following groups isolated vs. concurrent VMT vs. FTMH

CFT: CFT was higher in concurrent VMT compared to isolate; presence of concurrent ocular disease, as DR or Diabetic Macular Edema (DME), was associated with increased CFT. Kozak, et al. Showed no statistically significant difference in CFT between concurrent (407.1 ± 126.7 μ) vs. isolated (386.2 ± 162.9 μ) VMT [3].

Choroidal thickness: It showed higher values in concurrent group compared to isolate and FTMH. Unlikely, Kozak, et al. found that presence of concurrent ocular disease, such as DR or DME, was not associated with increase in choroidal thickness [3].

Focal vs. broad VMT: There was no significant difference between both types regarding CFT and choroidal thickness, in each of isolated and concurrent groups. On the other hand, Kozak, et al. Showed that with broader adhesion, forces appear to be less effective in achieving focal detachment. This same amount of traction may result in stretching choroid [3]. This broader adhesion was associated with increased choroidal thickness while when VMT diameter is narrower (focal), greater force is exerted upon fovea, facilitating spontaneous resolution of vitreous traction with no effect on choroidal thickness [3]. In the study by Bottos, et al. V-shaped and focal-VMT led to TCME and MH, while J-shaped and broad-VMT led to ERM and diffuse retinal thickening. Broad VMT was associated with significantly high CFT [4]. Koizumi, et al. found that focal VMT was associated with foveal cavitation, while broad VMT with CME [6].

VMT grades: We found no significant difference between 3 grades regarding CFT and choroidal thickness, in each of isolated, concurrent and FTMH. Kozak, et al., found no significant difference in CFT between mild and severe VMT, while central ($p=0.011$), nasal ($p=0.004$), and temporal ($p=0.02$) choroidal thickness was significantly higher in severe VMT compared to mild VMT [3]. There was significant difference in both CFT ($p=0.035$) and central ($p=0.005$), nasal ($p=0.01$), and temporal ($p=0.001$) choroidal thickness between moderate and severe VMT. Errera, et al. revealed statistically significant difference in baseline CFT between moderate and severe grades only ($P<0.05$) [7]. Regarding clinical course of VMT, John, et al. reported that in grade 1; spontaneous release occurred in 13 eyes, remained stable in 23 while it progressed to grade 2 in 7. In grade 2; spontaneous release was seen in 17 eyes, remained stable in 31 and progressed to grade 3 in 8 (3 of which had FTMH and had PPV). In grade 3; spontaneous release occurred in 4 eyes, improved to grade 2 in 1, remained stable in 1 and progress to FTMH in 1 [11]. Stalmans, et al. reported that disease progression was seen in 14 eyes (11.3 %) in VMA stage, with 6 eyes (4.8 %) developing MH. Eleven eyes (5.4%) in VMT stage developed MH, and 8 (15.1%) in MH with VMT evolved toward detachment. Spontaneous resolution was more with VMT (22.7 %) than VMA (7.3%) ($p<0.001$). PPV was resorted to in 47 eyes (88.7%) with MH with VMT, 152 (86.4

%) with MH without VMT, 52 (25.6 %) with VMT and 6 (4.8 %) with VMA [8].

Correlating each of mean CFT and average choroidal thickness and the following

VMTA: The current study showed moderately strong direct significant correlation with each of CFT and average choroidal thickness, in concurrent VMT group, where wider (more opened) VMTA were associated with increased CFT and average choroidal thickness, It has been reported that wider (more open) VMFA, leading to V-shape VMT, results in faster VMT resolution and is possibly associated with TCME and MH formation [3]. On the other hand, there was no significant correlation in isolated VMT and FTMH groups. Similarly, Theodossiadis, et al. also showed that wider VMT angle was associated with increased CFT [13]. Kozak, et al. found that wider (more open) angle was associated with increased CFT, but not choroidal [3].

VMA area: Our study showed no significant correlation with each of CFT and average choroidal thickness, in isolated and concurrent VMT groups. Bottos, et al. showed that CFT was slightly greater with J-shaped or broad VMT than in V-shaped or focal VMT [4]. Kozak, et al. found that broad VMT has thicker choroid than focal VMT, which has more open VMT angle, while they found no significant correlation between VMA area and CFT [3]. Regarding importance of diameter of VMA area and its effect on CFT, Charalampidou, et al. described TCME as mild subtype of VMT [14]. As in all subtypes of VMT, prognosis and treatment options depend on size and configuration of residual VMA and consequential macular anatomical changes. Extent of residual VMA also determines classification of VMT subtype. TCME is characterized by maximum diameter of VMA of no more than approximately 500 μ. Codenotti, et al. concluded that the more the VMA area reduced over time, the higher the chance of spontaneous resolution. Area <101002 μ2 was the threshold value indicating higher chance of spontaneous release [10]. Theodossiadis and colleagues (2014) analyzed the VMT natural course from VMA stage to spontaneous resolution. They found that likelihood of resolution was >99% lower for patients with VMT diameter > 400 μ. Broad VMT remained at same stage, while V-type VMT had 80% probability of resolution [13].

Posterior hyaloid thickness: Interestingly we had an inverse moderately strong significant correlation with average choroidal thickness in isolated group and a direct moderately strong significant correlation with average choroidal thickness in FTMH. There was no significant correlation with each of CFT and average choroidal thickness in concurrent VMT. Kozak, et al. analyzed posterior hyaloid membrane in isolation, not as part of complex with ERM or thickened ILM as in some VMA [3]. Different reflectivity of posterior hyaloid membrane signal, which may represent different membrane thickness, did not correlate with foveal or choroidal thickness. Therefore, study hypothesized that posterior hyaloid thickness did not contribute to amount of tensile traction, but instead it is configuration of traction that is responsible for amount of force pulling on macula.

BCVA: In our study there was an inverse moderately strong significant correlation with CFT in concurrent group and there was an inverse moderately strong significant correlation with average choroidal thickness in isolated group. Kozak, et al. showed that BCVA was not affected by CFT and choroidal thickness in VMT [3]. John, et al found that BCVA among 3 VMT grades at presentation was significantly different (P=0.012), with grade 3 worst. No significant differences were found between initial and final BCVA in each group [11]. Theodossiadis, et al. concluded that there was no significant difference in mean BCVA (P=0.052) and mean CFT (P=0.291) between baseline and final exam after vitreofoveal separation [13]. Bottos, et al. reported that BCVA was not significantly different between V-shaped (0.45; J-shaped, 0.46); and focal (0.50 and broad (0.42) [4]. Zhang, et al. showed that BCVA and CFT were moderately linear. (r=0.616, P=0.007) [5]. Errera, et al. concluded that relative risk of resolution increased with better presenting VA, lesser CFT, and no associated ERM. Poor vision increased odds of FTMH (by 12.89) and PPV (by 15.52) [7].

CFT correlated to average choroidal thickness: We had no significant correlation between them in each of isolated and concurrent groups. Kozak, et al. did not correlate CFT to choroidal thickness [3]. Factors affecting CFT and Average choroidal thickness. In our study, association with DR/AMD was found to be a significant risk factor for CFT, while BCVA was found to significantly affect choroidal thickness. Our results agreed with Kozak, et al. study, where DR was found to be significant for increased CFT, while they found that BCVA did not show any effect on average choroidal thickness [3]. Errera, et al. studied factors leading to FTMH or PPV. They found that age reduced odds of resolution by 0.94 and increases odds of stable VMT by 1.07, poor vision increased odds of FTMH by 12.89 and PPV by 15.52 and ERM reduced odds of FTMH by 0.08 but increased odds of PPV by 15.63 [7]. Our work was the only one, apart from Kozak, et al., to measure choroidal thickness and its correlation with other VMT parameters [3].

Conclusion

We found that choroidal thickness was statistically different among isolated, concurrent VMT and FTMH cases. Also, the wider the VMTA, the higher the choroidal thickness and CFT, in concurrent cases, while the thicker the posterior hyaloid, the less the choroidal thickness in isolated cases, while the thicker it was in FTMH. Based on functional outcome, the thicker the choroid, the less the BCVA, in isolated VMT cases. These results need further studies to correlate anatomical outcomes with more functional outcomes including visual field and microperimetry.

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- No association with commercial entities that could be viewed as having an interest in general area of submitted manuscript.
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Contribution Ship

Shoeib M Shoukry Shoeib: Acquisition and interpretation of data, drafting work.

Mohamad ASE Abdelhakim: Acquisition, analysis and interpretation of data, drafting work and revising it critically for important intellectual content, final approval of version published, agreement to be accountable for all aspects of work in ensuring that questions related to accuracy or integrity of any part of work are appropriately investigated and resolved.

Tamer A Macky: Acquisition, analysis and interpretation of data, drafting work and revising it critically for important intellectual content, final approval of version published, agreement to be accountable for all aspects of work in ensuring that questions related to accuracy or integrity of any part of work are appropriately investigated and resolved.

Soheir M Esmat: Conception and design of work, revising work critically for important intellectual content, and final approval of version published, and agreement to be accountable for all aspects of work in ensuring that questions related to accuracy or integrity of any part of work are appropriately investigated and resolved.

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