

ORIGINAL ARTICLE

VISUAL FUNCTIONS AND RETINAL MORPHOLOGY IN PATIENTS WITH POLYPOIDAL CHOROIDAL VASCULOPATHY SEEN IN AN AGE RELATED MACULAR DEGENERATION REFERRAL CENTRE OF MALAYSIA

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ABSTRACT

The aim of the present study was to evaluate visual functions and retinal morphology of Polypoidal Choroidal Vasculopathy (PCV) patients seen in an AMD referral centre of Malaysia and to further explore association between visual functions and optical coherence tomography (OCT) parameters in PCV eyes. In this single centre, cross sectional study, best corrected distance visual acuity (DVA), near vision acuity (NVA), reading speed (RS), and contrast sensitivity (CS) were measured in naïve PCV eyes. Selective parameters such as integrity of external limiting membrane (ELM), inner segment and outer segment junction (IS-OS), retinal pigment epithelium and Bruch's membrane (RPE-BM) complex, average retinal thickness (ART) and volume (ARV), central retinal thickness (CT), centre maximum (CTmax) and centre minimum (CTmin) thickness were assessed using spectral-domain OCT. Forty-three new PCV eyes of 42 patients were evaluated. Mean (\pm SD) DVA, NVA, CS, RS were 0.83 ± 0.35 logMAR, 0.77 ± 0.3 logMAR, $0.69 \pm .26$ log CS and 59.56 ± 14 words per minutes respectively. ART and CT showed good correlation with DVA ($r=0.571$ & 0.546) and CS ($r= 0.576$ & 0.586). ARV and CTmax showed good correlation with CS ($r=0.516$ & 0.513). The mean DVA, NVA and CS between three ELM and IS-OS status were significantly different ($p=.002$ & $.000$; $p=.012$ & $.029$; $p=.005$ & $.001$). In conclusion, present study reports visual functions and OCT characteristics of PCV patients in an AMD referral centre of Malaysia. Many of the quantitative and qualitative OCT parameters showed good association with the visual functions in eyes with PCV.

Keywords: polypoidal choroidal vasculopathy, visual functions, ocular coherence tomography

INTRODUCTION

Polypoidal Choroidal Vasculopathy (PCV) is often described as a subtype of neovascular Age-related macular degeneration (n-AMD) with almost similar clinical manifestation as the typical n-AMD^{1,2}. It is more prevalent in Asia being accountable for considerable amount of visual impairment³⁻⁶.

Polypoidal lesions and Branch vascular network (BVN) seen in indocyanine green angiography (ICGA) in PCV eyes are considered as gold standard to differentiate PCV from typical n-AMD as these distinct characteristics are not seen in typical n-AMD eyes. In high resolution Optical Coherence Tomography (OCT), besides exhibiting atypical pigment epithelium detachments (PEDs) that may or may not be associated with sub retinal fluid and sub retinal tissues, PCV is characterised by polypoidal lesions attached to the pigment epithelium detachment, BVN seen in lower PED and increased Choroidal thickness^{1,7}.

Impact of PCV on visual functions may vary depending on the extend and location of the pathologies seen. Few previous researchers reported that initial VA in PCV is better than those with typical n-AMD^{2,8}. Another study that examined 17 eyes with PCV revealed the range of initial VA was from 1/200 to 20/50⁷. However, high contrast visual acuity alone does not represent the overall visual status of the eye. For example vision specific activities of a person may get affected when contrast sensitivity is impaired although having a near normal visual acuity score⁹.

Although different visual functions including distance and near visual acuity, contrast sensitivity and reading speed of n-AMD have been studied in detail in previous researches^{10,11}, no study has focused on other visual functions apart from high contrast distance visual acuity in PCV patients. Many of the studies in PCV patients used best corrected distance visual acuity as the primary

determinant of visual function rather than considering other visual components representing macular function while assessing characteristics and treatment outcome of PCV^{2,12}.

Thereby, the purpose of this observational study was to evaluate visual functions along with morphological characteristics of PCV patients seen in an AMD referral centre in Malaysia. Furthermore, an association between OCT parameters and visual functions in these patients were also evaluated.

METHODS

In this single centre, cross sectional study, patients diagnosed with PCV in at least one eye without any intervention were recruited from the ophthalmology department of a public hospital which is also an AMD referral centre of Malaysia from December 2016 to July 2017. Presence of any retinal pathology other than PCV such as diabetic retinopathy, retinal vein occlusion, macular hole, any type of maculopathy and any neurodegenerative disease such as Alzheimer's disease, dementia that may affect the visual parameters were excluded. Diagnosis of PCV was done based on the description of a Japanese study whereby there is presence of polypoidal lesions with or without BVN viewed with ICGA¹³. However, in patients where ICGA was not performed due to reasons like patient's allergy to indocyanine, OCT parameters were taken into consideration as many previous researches reported spectral-domain (SD) OCT has an excellent sensitivity and specificity to detect PCV^{14,15,16}. The present study followed the diagnosis criteria described by Zhang and associates in 2016¹⁶. Thus, OCT parameters such as sharp retinal pigment epithelium detachment peak, double-layer sign, multiple retinal pigment epithelium detachment, a retinal pigment epithelium detachment notch, a hyporeflective lumen representing polyps, and hyper reflective intraretinal hard exudates were considered. Among the 6 above mentioned features of SD OCT, presence of first two features and at least one of the other features was considered as the diagnosis of PCV; in the absence of the first two features, the diagnosis of PCV was also made when at least 3 of the other features were present¹⁶. All the diagnosis was confirmed by a senior ophthalmologist (RS) for recruitment of the study patients. All other recordings were conducted by a single well-trained optometrist (RG).

Ethical approval was obtained from Medical Research and Ethics Committee (NMRR-16-1965-31826 (IIR)) and Universiti Kebangsaan Malaysia Research and Ethics Committee (UKM

1.5.3.5/244/NN-186-2014) which follows the tenants of Helsinki. Written consent was obtained from all the participants.

I. Visual functions

A 4-meter early treatment diabetic retinopathy study (ETDRS) chart was used to measure the best corrected distance visual acuity (DVA). If any of the subjects was not be able to read the top line, then the chart was moved to 3, 2 and 1 meters until the patient could read the top line. Pelli-Robson chart was used at 1 meter to measure the contrast sensitivity (CS). CS was recorded based on the contrast of last group in which two or three letters were correctly read. Near visual acuity (NVA) and reading speed (RS) were recorded using a UiTM Malay related-word reading chart¹⁷. NVA was recorded as the threshold or the smallest print size that was read correctly by the patient with best spectacle correction whereas reading speed was recorded by dividing the number of words that were read correctly with the time taken to read in words per minute. While measuring the near acuity and reading speed, the method recommended by the chart developers were followed¹⁷.

II. Optical coherence tomography (OCT)

All participants underwent spectral-domain OCT (Spectralis HRA+OCT Heidelberg Engineering Inc, Heidelberg, Germany) examination. Macular volume scan was performed in all eyes. Presence of the pathologies including pigment epithelium detachment (PED), Sub retinal fluid (SRF), intra retinal fluids (IRF), sub-retinal fibrinous tissue (SRT) were noted.

Qualitative and quantitative analysis of OCT images at 1 mm centre of the fovea were performed by RS and RG at different points of time in different order in a masked fashion. For qualitative analysis of OCT image, firstly, the fovea was detected and the software Calliper was placed at the centre of the fovea. Thereafter, 500 micron section in either direction from the foveal centre was evaluated.

Previous researches have evaluated integrity of different retinal morphological parameters such as external limiting membrane, photoreceptor's inner segment outer segment junction in typical n-AMD to identify morphological features that represents visual functions in those eyes^{18,19}. In the present study, the qualitative parameters that were assessed in 1000 micron (1mm) of fovea are as follows:

1. Integrity of inner segment and outer segment (IS-OS) junction:

- a. Present: When 75 % or more part of IS-OS junction were present
 - b. Absent: When 75% or more part of the IS-OS junction were absent
 - c. Discontinuous: When more than 25% but less than 75% part of IS-OS junction were present
2. Integrity of external limiting membrane (ELM)
 - a. Present: When 75 % or more part of ELM were present
 - b. Absent: When 75 % or more part of ELM were absent
 - c. Discontinuous: When more than 25% but less than 75% part of ELM were present
 3. Integrity of retinal pigment epithelium and Bruch's membrane (RPE-BM) complex
 - a. Intact: When 75 % or more part of RPE-BM complex were present
 - b. Completely separated: When 75 % or more part of RPE-BM complex were separated
 - c. Partially separated: When more than 25% but less than 75% part of RPE-BM complex were intact

Furthermore, quantitative parameters including average retinal thickness (ART) and volume (ARV), central thickness (CT), centre maximum (CTmax) and centre minimum thickness (CTmin) were measured from the OCT thickness map using the incorporated software of Spectralis OCT. ART and ARV were measured as of average thickness and volume of central 1 mm of ETDRS grid; whereas CT was measured as the centre thickness of the grid's centre pixel considering the distance between internal limiting membrane and RPE BM complex. Here CT is the central foveal thicknesses as the centre grid is placed at the centre of the fovea. CTmax and CTmin are the maximum and minimum thickness value of central 1mm circle ETDRS.

III. Statistics

All the data were analysed using SPSS software IBM SPSS 17; SPSS Inc. USA. Inter observer

variability of the OCT parameters were tested for both qualitative and quantitative data using Cohen's kappa (k) and intra class correlation (ICC) respectively. Two examiners participated in inter-observer study where one examiner (Examiner 1, RG) had experience in analyzing the OCT images manually and automatically. The other examiner (Examiner 2, RS) was an experienced retina specialist who had ample experience in all retinal diagnostics including OCT. While analyzing the OCT images, the examiners were masked about the other clinical details of the patients including FFA, ICGA or fundus findings and visual functions. They independently analyzed all the images at different times to ensure no discussion on the image analysis was made. Descriptive statistics and Analysis of Variance (ANOVA) was employed to compare the visual functions between groups based on the status of qualitative OCT parameters such as integrity of IS-OS, ELM and RPE-BM complex. Pearson's correlation was employed to assess the association between different quantitative OCT parameters and visual functions.

RESULTS

Forty-three (43) newly diagnosed PCV eyes of 42 patients (23 males and 19 females) aged between 51 to 85 years were evaluated in this study. Four (4) patients were already undergoing treatment for PCV in the other eye. A total 5 subjects (11.90%) had bilateral PCV.

Visual functions

Majority of the eyes revealed moderate impairment in distance and near visual acuity. Twenty-four (24) eyes showed DVA worse than 0.5 to 1 logMAR whereas 23 eyes showed NVA of worse than 0.5 to 1 logMAR. Twenty-one (21) eyes showed log contrast sensitivity between 0.75 to 1.05. Reading speed was measured in 29 subjects, of which, 17 of the subjects showed reading speed of 51 or more words per minute. Descriptive statistics of visual functions of the study eyes are shown in Table 1.

Table 1 : Description of visual functions of PCV eyes

| Parameters | Mean ±SD | Range |
|-------------------------|-------------|--------------|
| DVA (logMAR), n=43 | 0.83 ± 0.35 | 0.3 to 1.62 |
| NVA (logMAR), n=42 | 0.77 ± 0.31 | 0.3 o 1.3 |
| CS (log CS unit), n=43 | 0.69 ± 0.26 | 0.15 to 1.35 |
| RS (wpm), n=29 | 59.56 ± 14 | 7 to 110 |

SD= Standard deviation, n= number of eyes, DVA= Best corrected distance visual acuity, NVA= Near visual acuity, CS= Contrast sensitivity, RS= Reading speed

OCT Features

Quantitative and Qualitative measurement

In the present study, all the patients had PEDs with different size and shape. PEDs varied from small bumpy to large dome-shaped PEDs. Figure 1 (A to E) represents PEDs of different size and shape. Thirty-eight (38) patients had presence of sub-retinal fibrinous tissue (SRF), whereas 5 subjects had intra-retinal fluid (IRF) and another 5 subjects showed sub-retinal fibrinous tissue (SRT).

However, out of 43 eyes, exact location of fovea was detectable only in 38 eyes. Thus, quantitative and qualitative parameters used in the study were assessed in those 38 eyes.

Inter-observer reliability was high for all measured foveal characteristics: ART (ICC =0.996), ARV (ICC=0.988), CT (ICC =0.996), CTmax (ICC =0.922), CTmin (ICC =0.922), integrity of ELM (k=0.814), IS-OS (k=0.814), junction and RPE complex (k=0.879).

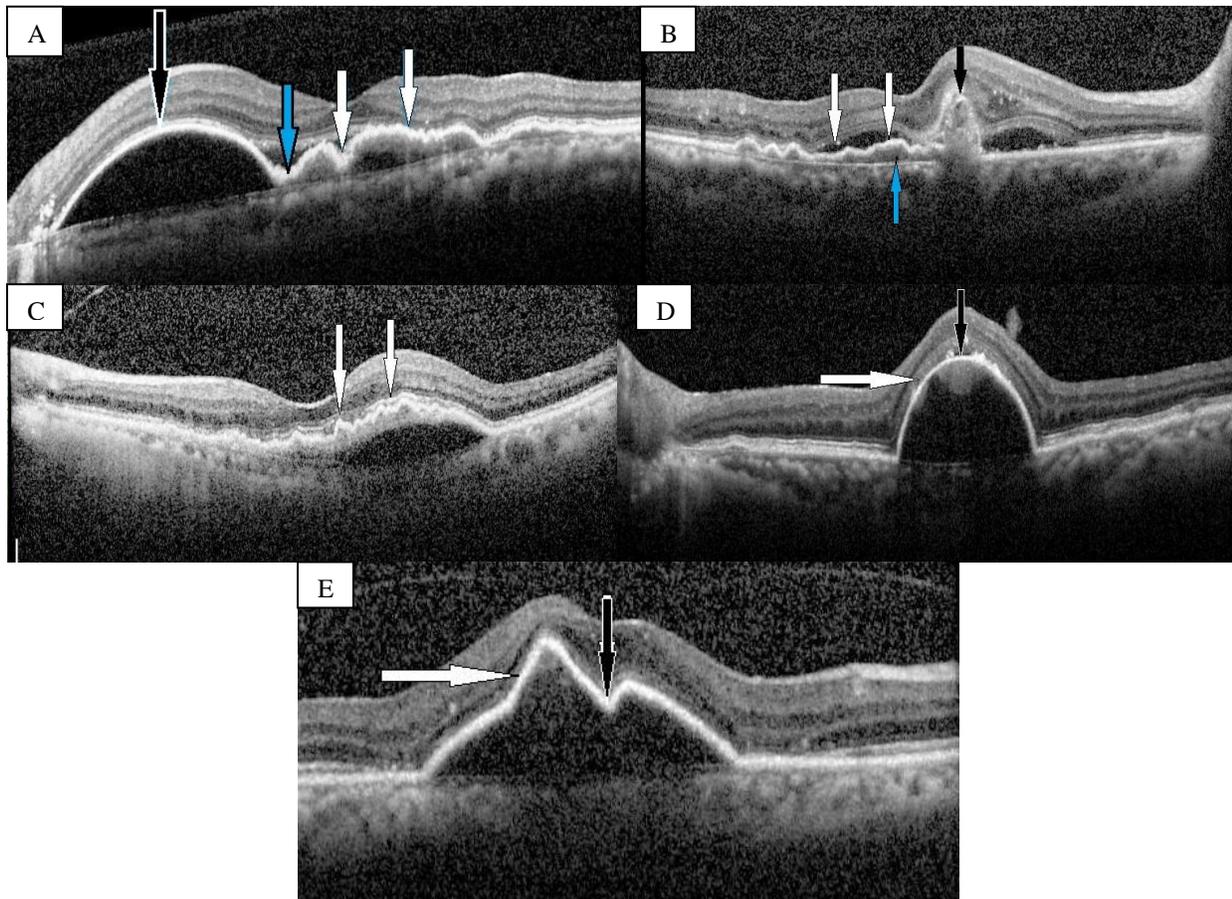


Figure 1:

- A: A large pigment epithelium detachment (large black arrow) attached to small bumpy PEDs (small white arrows). Tomographic notch (blue arrow) is present here;
- B: Medium sized hemorrhagic pigment epithelium detachments (black arrow) attached to small bumpy pigment epithelium detachment (white arrows). Double layers sign (blue arrow) is present here;
- C: Flickering pattern pigment epithelium detachments (white arrows);
- D: A large dome shaped pigment epithelium detachment (white arrow) with focal medium reflective areas (polyp) (black arrow) attached to it;
- E: M shaped pigment epithelium detachment (white arrow) with tomographic notch (black arrow)

Integrity of ELM, IS-OS and RPE BM complex at central 1000 micron of fovea: Fourteen (14) eyes had ELM present, 7 eyes had discontinuous ELM and 17 eyes had ELM absent. Integrity of IS-OS was grouped into present, discontinuous and absent. Fifteen (15) eyes had IS-OS present, 6 eyes had

discontinuous IS-OS and 17 eyes had IS-OS absent. RPE-BM complex were intact in 9 eyes, partially separated in 11 eyes and completely separated in 18 eyes. Figure 2 (A to D) describes the different status of ELM and IS-OS at 1000 micron in fovea.

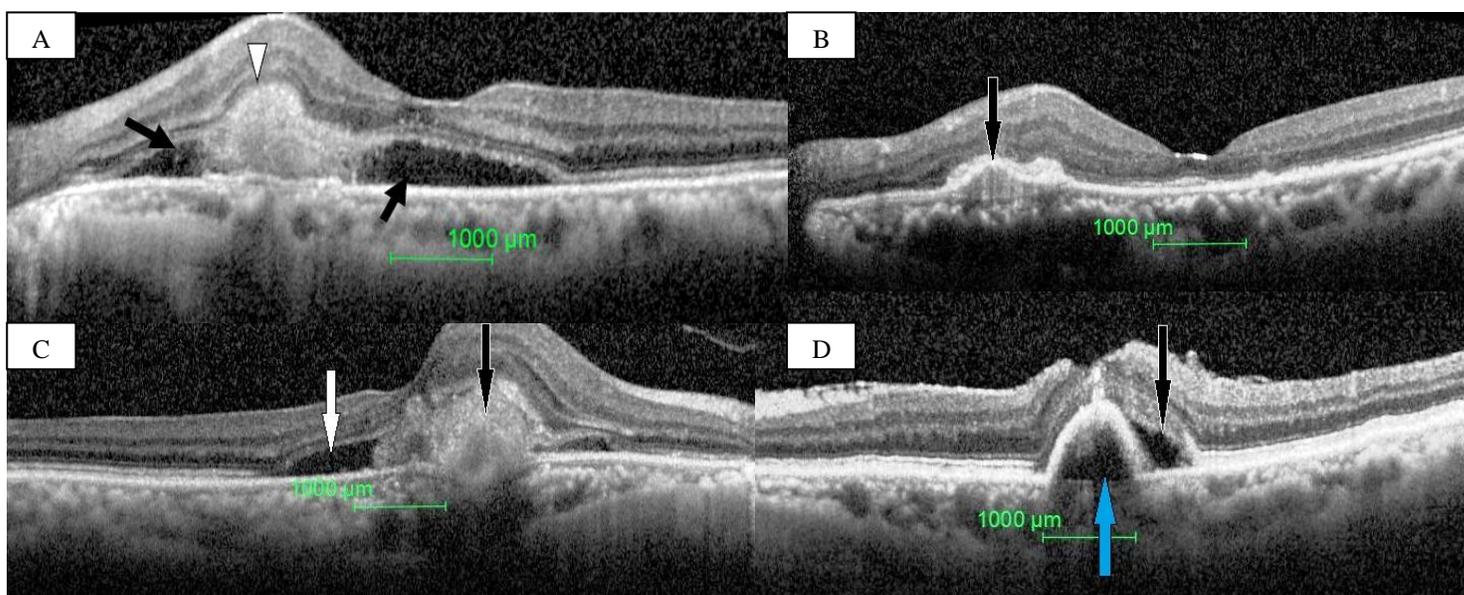


Figure 2: Describe different status of external limiting membrane (ELM) and inner segment- outer segment (IS-OS) at 1000 micron in fovea.

- A: Sub retinal fluid (black arrows) and sub retinal blood (white arrow head) is seen in this picture. Both ELM and IS-OS junction are present.
- B: Small extra foveal pigment epithelial detachment (PED) (black arrow) is seen here. ELM is 100% present, IS-OS is discontinuous
- C: A fibro vascular pigment epithelial detachment (black arrow) with sub retinal fluid (SRF) (white arrow) is seen here. ELM is absent, IS-OS is discontinuous.
- D: A medium sized pigment epithelial detachment (blue arrow) with sub retinal fluid (black arrow) is seen here. A faint ELM is present and IS-OS is absent

The quantitative retinal parameters are described in Table 2.

Table 2 : Quantitative OCT parameters in PCV eyes

| OCT parameters (n=38) | Mean ±SD | Range |
|------------------------|-----------------|--------------|
| ART (micron) | 416.34 ±136.64 | 180 to 683 |
| ARV (mm ³) | 0.3 ± 0.13 | 0.14 to 0.59 |
| CT (micron) | 401.42 ± 164.08 | 136 to 811 |
| CTmax (micron) | 507.81 ± 202.75 | 241 to 830 |
| CTmin (micron) | 334.57 ± 117.05 | 127 to 634 |

SD= Standard deviation, n= number of eyes, ART=average retinal thickness, ARV= average retinal volume, CT= central thickness, CTmax= maximum thickness of central 1mm ETDRS grid, CTmin= minimum thickness of central 1 mm ETDRS grid

Correlation of visual functions with quantitative OCT parameters

DVA showed good correlation with ART and CT (r > 0.5). NVA showed moderate correlation with ART, ARV, and CT (r = 0.358, 0.371, and 0.354

respectively). CS showed good correlation (r > 0.5) with all the OCT parameters except CTmin, which showed modest correlation (r = -0.373). However, reading speed did not show any correlation with any of the OCT parameters. (refer to Table 3)

Table 3 : Relationship between visual parameters and quantitative OCT parameters.

| | ART | ARV | CT | CTmax | CTmin |
|-----|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| DVA | r = 0.571 p = 0.00 | r = 0.283 p = 0.00 | r = 0.546 p = 0.85 | r = 0.449 p = 0.005 | r = 0.426 p = 0.008 |
| NVA | r = 0.358 p = 0.03 | r = 0.371 p = 0.026 | r = 0.354 p = 0.034 | r = 0.238 p = 0.162 | r = 0.165 p = 0.337 |
| CS | r = -0.576 p = 0.000 | r = -0.516 p = 0.000 | r = -0.586 p = 0.000 | r = -0.513 p = 0.001 | r = -0.373 p = 0.021 |
| RS | r = -0.134 p = 0.533 | r = -0.170 p = 0.427 | r = -0.133 p = 0.536 | r = 0.135 p = 0.530 | r = 0.080 p = 0.711 |

r= Correlation coefficient, p-values are statistically significant (p<0.05), ART=average retinal thickness, ARV= average retinal volume, CT= central thickness, CTmax= maximum thickness of central 1mm ETDRS grid, CTmin= minimum thickness of central 1 mm ETDRS grid

Association between visual functions and qualitative OCT parameters

ANOVA showed that mean DVA, NVA and CS between three ELM status and IS-OS status were significantly different (refer to Table 4). However, RS showed significant difference between the three ELM statuses only but not the IS-OS status. Nevertheless, integrity of RPE-BM complex showed no association with visual functions (p> 0.05).

Furthermore, post hoc analysis between groups showed mean DVA (0.58), NVA (0.59) and CS (0.88)

were significantly better (p=0.002, 0.010 and 0.005 respectively) in eyes where ELM was present compared to the mean DVA (0.99), NVA (0.90) and CS (0.57) in eyes with absent ELM. Similarly, eyes with intact IS-OS showed significantly better (p=0.00, 0.029, 0.001 respectively) mean DVA (0.63), NVA (0.62) and CS (0.85) compared to eyes where IS-OS were absent (DVA =1.06, NVA =0.89, CS=0.5). Significant difference (p=0.019, p=0.04 respectively) in mean DVA and CS between IS-OS disrupted (mean DVA=0.67, mean CS=0.80) and absent (mean DVA=1.06, mean CS=0.51) group were also observed.

Table 4 : Association between visual functions and qualitative OCT parameters

| | Integrity of ELM | | | Integrity of IS-OS | | |
|---------|------------------|---------------|---------------|--------------------|---------------|--------------|
| | Present | Discontinuous | Absent | Present | Discontinuous | Absent |
| DVA | | | | | | |
| n | 14 | 7 | 17 | 15 | 6 | 17 |
| Mean±SD | 0.58 ±0.18 | 0.92 ±0.23 | 0.99 ±0.38 | 0.63±0.24 | 0.67±0.32 | 1.06±0.32 |
| F (df) | 7.265(2) | | | 10.207 (2) | | |
| p-value | 0.002 | | | 0.000 | | |
| NVA | | | | | | |
| n | 14 | 7 | 16 | 15 | 6 | 16 |
| Mean±SD | 0.59±0.24 | 0.81±0.26 | 0.90 ±0.29 | 0.62±0.24 | 0.78±0.34 | 0.89 ±0.28 |
| F(df) | 5.11(2) | | | 3.632 (2) | | |
| p-value | 0.012 | | | 0.029 | | |
| CS | | | | | | |
| n | 14 | 7 | 17 | 15 | 6 | 17 |
| Mean±SD | 0.88± 0.16 | 0.61 ±0.28 | 0.57 ±0.30 | 0.85±0.15 | 0.80±0.16 | 0.51 ±0.31 |
| F(df) | 6.238(2) | | | 8.742(2) | | |
| p-value | 0.005 | | | 0.001 | | |
| RS | | | | | | |
| n | 8 | 5 | 11 | 11 | 4 | 9 |
| Mean±SD | 77.00 ±16.8 | 48.60±20.68 | 55.18 ± 23.03 | 71.18 ±19.46 | 57.25 ±37.69 | 50.44 ±15.54 |
| F(df) | 3.723(2) | | | 2.313(2) | | |
| p-value | 0.041 | | | 0.124 | | |

SD = standard deviation. n= Number of subjects. F= F-statistics. df= Degree of freedom, p-values are statistically significant (p<0.05). ELM=external limiting membrane (ELM), IS-OS=inner segment and outer segment junction

DISCUSSION

To the best of our knowledge, this is the first study in Malaysia to report the clinical characteristics of PCV patients seen in an AMD referral centre. Although many studies from Singapore, Japan, China, and Korea^{2,4-6} have reported extensively on PCV patients, none of them reported other visual function in these patients except visual acuity. Thus, the present study reported the visual functions including DVA, NVA, CS, and RS of new PCV eyes for the first time.

In the present study, 43 newly diagnosed PCV eyes of 42 patients were evaluated. Majority of the eyes (72.09 %) had mild to moderate visual impairment with DVA being 6/12 to 6/60 whereas 27.90 % of the eyes had severe visual impairment with DVA of less than 6/60. Mean DVA of the PCV eyes was 0.83 ± 0.35 logMAR. This finding is almost similar to the findings of Cheung et al.² who reported a mean DVA of 0.78 logMAR in PCV eyes among Singaporeans. However, Chinese, Japanese and Korean studies reported a better mean presenting DVA of 6/18 (0.5 logMAR), 20/60 (0.5 logMAR) and 0.231 logMAR respectively⁴⁻⁶.

Near vision measured with UiTM Malay related-word reading chart varied from 0.3 (N6) to

1.3(N40) logMAR. However, 23 eyes revealed a NVA between N12 to N32. The reason behind majority of the eyes showing mild to moderate VA both in distance and near acuity, can be because of the fact that PCV lesions in initial stages remain below RPE not affecting the integrity of neuro-retina. However, with advancing stages of PCV, visual acuity may worsen resulting from progression of the disease. Thus, the presenting VA depends on the stage of the disease presentation¹. Thereby, in the present study, the range of DVA and NVA varied from mild to severe impairment.

Furthermore, reading speed that was measured only in 29 eyes varied from 7 to 110 words per minute. Calabrese and associates reported that average reading speed of normally sighted individuals at 40 years was 200 words per minute. However, above 40 years of age, it gradually decreased to 175 words per minute at the age of 81²⁰. In view of this, we can state that all the PCV eyes in the present study showed impaired reading speed. Furthermore, Altinbay and associates reported maximum reading speed between 0 to 103 words/min in 27 AMD patients²¹. However, reading speed did not correlate with any of the quantitative OCT parameters, although it showed significant association with integrity of ELM.

Conversely, Pelli-Robson contrast sensitivity measures person's ability to discriminate between different contrast images and is assessed using same sized letters consisting of different contrast²² whereas visual acuity is the measure of vision that is assessed using high contrast Snellen's or logMAR chart. In some instances, CS represents useful measures of visual function of an individual more than visual acuity does^{9, 23}. For example, visual performance such as driving was more strongly predicted by contrast sensitivity than visual acuity measured under standard photopic conditions²³. Results from radiation therapy for age related macular degeneration studies suggested both visual acuity and CS should be evaluated as outcome measure in interventional studies as both parameters reveal essential information of visual difficulties encountered by the diseased individual²⁴. Mantyjarvi and associates noted a mean CS score of 1.68 log CS using Pelli-Robson chart in non-diseased eyes for the age group of 60 years and above²⁵. Thereby, a CS score of less than 1.65 is considered as impaired CS in this age group. In the present study, all patients showed impairment of CS. Fifteen (15) patients showed severely impaired contrast sensitivity between 0.15 to 0.60 logMAR. Among them, 6 patients showed a CS score of as low as 0.15 logMAR. Many researches adopted CS as one of the major parameters while assessing the treatment outcome of neovascular AMD but not in PCV. Keane and associates reported a strong association between decrease CS with increased sub retinal tissue in 152 newly diagnosed n-AMD patients suggesting CS is one of the parameters relevant to functional improvement and disease prognosis¹¹. Nixon and associates reported improvement of CS when the n-AMD patients were shifted to aflibercept from ranibizumab although VA was stable²⁶. Similarly, Kumar and associates reported CS to be the improved visual parameter in n-AMD subjects undergoing photodynamic therapy (PDT) with verteporfin along with intravitreal triamcinolone acetonide (IVTA)²⁷. Likewise, in the present study, CS showed maximum correlation with the retinal quantitative parameters used in this study. This indicates that CS plays a major role in representing the morphological damage in PCV eyes as reported in typical n-AMD. Thereby, the present study emphasizes that assessment of CS should be included while assessing the impact of disease on visual functions in PCV patients.

Clinical characteristics of PCV vary from typical n-AMD^{1,8,15}. In the present study, all the patients had PEDs with different texture. Thirty-eight (38) subjects had SRF and 4 subjects had IRF. Another 5 subjects showed subretinal fibrinous material. Additional findings like obvious polypoidal reflex,

double layer sign and tomographic notch were also observed. Similarly, Alshahrani and associates showed PED with SRF in all of the 17 eyes examined with PCV and IRF were present in 12 eyes⁷. A Korean study reported serous or hemorrhagic PED (43 eyes), followed by intra retinal oedema (8 eyes), subretinal fluid (20 eyes), and subretinal haemorrhage (2 eyes) in 45 eyes where OCT was performed⁶.

Another major aim of the study was to draw association between visual functions and OCT parameters in eyes with PCV. While assessing the correlation between visual and morphological parameters in AMD, many of the previous researches reported ART, CRT and ARV were not suitable OCT parameters to correlate with visual functions¹⁰. Conversely, Henschel and associates found a significant correlation between decreased VA with increased retinal thickness²⁸. Likewise, in a recent study, Nixon and associates observed a significant correlation between changes in CS with CRT change in patients with AMD shifted from aflibercept to ranibizumab²⁶. Furthermore, another study reported central macular thickness in OCT to be one of the predicting factors in final visual outcome of both typical AMD and PCV patients in Asia². In the present study, correlation between morphological parameters and visual function were assessed with cases when exact location of fovea was detectable. ART and CT showed good correlation with DVA and CS and a modest correlation with NVA. ARV, CTmax and CTmin showed good correlation with CS. However, none of the quantitative OCT parameters were correlated with reading speed.

In PCV, thickening of retinal parameters occur following PED, SRF and other pathology that leads to impairment of visual functions. Thus, our study results indicate these quantitative OCT parameters can be used to explain the vision loss of these patients to some extent. However, quantitative OCT parameters may not fully explain the visual impairment in the affected eyes, may be, because it is related to the varied structural characteristics of the disease. Thus, we tried to determine the association between some of the qualitative OCT parameters and visual functions. In the present study, while assessing the qualitative parameters, integrity of ELM has emerged as an important parameter in eyes with PCV. All the visual functions including reading speed were significantly better in eyes where ELM was present in at least 75 % of central 100 micron of fovea. Chhablani and associates reported a similar finding where integrity of ELM emerged as the only predictor of visual outcomes in patients undergoing anti-VEGF treatment in wet AMD¹⁸. Similarly,

Roberts and associates also found integrity of ELM as the only morphological predictor of BCVA at baseline, 6 months and 12 months follow up of 20 wet AMD patients undergoing anti-VEGF injections¹⁹. ELM is thought to act as a link between the Muller cells and the photoreceptors. Muller cells controls neuronal activity and also guide the lights towards the photoreceptors. So when the ELM is damaged, the normal connections between the photoreceptor and Muller cells is hampered that results into the structural and functional dysfunction of photoreceptors leading to impairment of vision^{29,30,31}.

Furthermore, integrity of photoreceptors is also thought to be associated with the integrity of IS-OS junction^{31,32}. In the present study, DVA, CS and NVA were significantly worse in eyes where IS-OS was present in less than 25 % of central 100 micron of fovea. This finding is supported by Roberts and associates who reported a significant correlation between IS-OS integrity and best corrected distance visual acuity in n-AMD patients at base line, 6 months and 12 months of treatment¹⁹. Likewise, Chhablani and associates reported IS-OS along with ELM and pre-treatment BCVA to predict 37 % of visual outcome in n- AMD treatment patients¹⁸.

However, integrity of RPE-BM complex was not associated with any of the visual functions. This is because of the fact that presence of PED may not necessarily result in disruption between RPE and photoreceptor affecting the function of photoreceptors. Similar results were reported by Keane and associates where no association between PED volume and CS or reading speed were observed¹¹.

However, types of PEDs that may be associated with visual function were not assessed in the present study. Furthermore, increased sample size in each group while assessing integrity of ELM and IS-OS could have enhanced the understanding of their association with visual functions. These can be considered as some of the limitations of the present study.

CONCLUSIONS

The present study reports visual and OCT characteristics of PCV patients seen in an AMD referral centre of Malaysia. CS showed good association with almost all the quantitative and qualitative OCT parameters used in the study. Similarly, ART and CT showed good correlation with DVA and CS. Although quantitative parameters alone could not fully explain the impairment of the visual functions, integrity of

ELM and IS-OS showed good association with the visual functions in eyes with PCV.

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