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Quantification of Macular and Peripapillary Vascular Density in Myopia Using Optical Coherence Tomography Angiography

Sabah Saad Eldressi[1], Salsabiel Elzaidi[2], Sara Bogazia[3]

[1]Department of ophthalmology, Faculty of medicine, Benghazi university, Libya
Email: *dr.abdullhalshref2000[at]gmail.com*

[2]Department of ophthalmology, Faculty of medicine, Benghazi university, Libya
Email: *salsabiel.elziadi[at]uob.edu.ly*

[3]Department of Oral Biology, Faculty of Dentistry Ajdabiya University, Ajdabiya, Libya,
Email: mera1987ly[at]gmail.com

Abstract: ***Background**: Myopia is a leading cause of correctable visual impairment worldwide, with its prevalence rapidly increasing, particularly in Asia. High myopia (spherical equivalent > -6.00 D) is associated with structural ocular complications that can result in permanent visual loss. Optical coherence tomography angiography (OCTA) allows non-invasive, high-resolution evaluation of retinal and peripapillary vascular changes in myopic eyes. This study aimed to evaluate macular and peripapillary vessel density changes among myopic adults using OCTA and identify associated factors. **Methods**: A prospective cross-sectional study was conducted from December 2023 to April 2024 involving 60 eyes of myopic adults (18–42 years) at an eye clinic center. Participants were grouped by myopia severity: mild, moderate, and high. OCTA was used to measure vessel density in five macular and peripapillary regions. Statistical analysis included ANOVA and Pearson's correlation. **Results**: Significant reductions in macular and peripapillary vessel densities were observed in high myopia, particularly in nasal and temporal areas (p<0.0001). Vessel density correlated positively with spherical equivalent and negatively with axial length. **Conclusion**: Vascular alterations increase with myopia severity. OCTA is a valuable tool in detecting early microvascular changes, emphasizing its role in the monitoring and management of myopic progression.*

Keywords: myopia, macular vascular density, peripapillary vascular density, optical coherence tomography angiography, retinal blood flow.

1. Introduction

Myopia is the most common prevalent eye disorders and is estimated to affect 1.5 billion people worldwide.[1] The prevalence of myopia is approximately 26.5% in adults and 11.7% in children. With the rapid development of internet and information technology, recent epidemiological studies have reported an increase in the prevalence of myopia, especially in Asian countries.[2] As indicated by the World Health Organization survey, it estimated that 49.8% of the global population will have myopia by the end of 2050.And it is defined as a major cause of correctable visual impairment, affecting mostly younger individuals around the world.[3,4] Myopia with a spherical equivalent refractive error > − 6 diopters (D) and/or an axial length (AL)>26 mm is defined as high myopia (HM), which is a risk factor for several ocular pathologies, such as choroid chorioretinal atrophy, neovascularization, retinal detachment, lacquer cracks, macular hole, epiretinal membrane, posterior staphyloma, Fuchs spot, hemorrhage, and macular neovascularization which are the reasons for low visual acuity and blindness. On the other hand, the changes and interaction between the peripapillary and optic nerve head (ONH) vascular circulation and retinochoroidal capillary network. In addition. Examination of the ocular vasculature previously has been a challenge due to limitations of several imaging modalities. Such as, fluorescein angiography (FA) is an invasive examination that cannot be accurately quantified.[5] Doppler imaging focuses on large vessels, rather than microvasculature that guide the development of examination, treatment and prevention options. The previous development of optical coherence tomography angiography (OCTA) makes it able to perform measurements of the retinal vasculature in a non-invasive manner. OCTA is a new imaging technique that employs motion contrast imaging non-invasively to obtain high-resolution volumetric blood flow by generating angiographic images without the use of exogenous intravenous dye injection.[6-8] OCTA with integrated software provides detailed quantitative measurement such as (vessel density (VD), perfusion density, foveal avascular zone (FAZ), choroidal thickness, and peripapillary thickness) with morphological information of the retinal vasculature system, involved both large retinal vessels ,retinochoroidal, peripapillary vascular circulation and the microvasculature, [9] which can extend the understanding of retinal blood flow in myopia.

2. Aim of the Study

This study aimed to evaluate the macular vascular flow density and peripapillary vascular density changes of myopic eyes among mid aged adult using optical coherence tomography angiography and the factors affecting these changes.

3. Methodology

3.1 Study design

Prospective cross-sectional design conducted between December 1, 2023, and April 30, 2024, at the Benghazi Eye

Hospital.

3.2 Participants

The study was carried out among all the myopic patients attending eye clinic center. Inclusion criteria were the entire participant aged from 18 -42 yrs from both gender presented with myopia without maculopathy, BVCA ≥ 6/12 and spherical equivalent ≥-0.5D. Participants with poor imaging quality (signal strength index ≤ 50), IOP>21 mmHg, previous ocular surgery, preexisting ophthalmic pathologies (pathological or degenerative myopia), ocular diseases affecting on circulation (glaucoma, retinal artery and vein occlusion) and systemic chronic disease which can cause retinopathy, such as metabolic disorders (diabetes mellitus, hypertension, etc.) were excluded from the study.[10]

3.3 Procedure

All participants underwent full ophthalmological examination, including measuring visual acuity using E chart, auto refractometer, best corrected visual acuity (BCVA) measurement, IOP measurement using Goldmann applanationtonometry, and slit lamp biomicroscopy, fundus examination by using + 90 lens, axial length was measured using Topcon Aladdin HW3.0 and the macular and peripapillary vascular density were measured using optical coherence tomography angiography OCTA using Topcon DRI triton swept source OCT. A detailed medical background was obtained and all participants who were enrolled in the study but not selected as the final participants were given thorough explanation of the exclusion criteria to avoid confusion, myopic eyes were not included if they had a history of other retinal diseases, intraocular surgery, or laser treatments as mention previously. The study included only patients with myopia and no pathological myopia or other high myopic complications. The patients' eyes divided into 3 groups categorized according to refraction spherical equivalent as the following 1-mild myopia (-0.5 -3.00 D),2-moderate myopia (-3.25 -6.00D) 3- high myopia (≥ -6.00D). [11]

3.4 Macular and peripapillary vessels density assessment by Optical coherence tomography angiography (OCT-A)

All OCTA scans were performed using the Topcon DRI Triton Swept Source OCT system, and vascular density measurements were analyzed with IMAGEnet 6 software (version 1.02.2). To minimize inter-observer variability, all OCTA imaging was performed by a single experienced examiner. In this study the Macular and peripapillary vessels density imaged, measured and undertaken by OCTA (swept source OCT DRI triton) with (OCTARA) algorithm. Device with a scan rate of 100,000 A-scans/s, angio scan protocol was performed as 3D (3.0×3.0mm - 320×320). The retinal microvascular flow network was assessed quantitatively by vessels density measurements obtained from OCTA image and the OCT DRI triton software (IMAGEnet 6 version 1.02.2) provide the analysis of the measurements. In addition, the macular regions divided into five regions: nasal, inferior, temporal, central and superior.

3.5 Statistical Analysis

All the data were analyzed and compared using the statistical package for social science SPSS version 22.0. (IBM Corp. Armonk, NY), and the measured values are expressed as mean and stander deviation. Data were analyzes using one- way analysis of variance, person's correlation coefficient, and multivariate liner regression analysis. Statistical significance was defined as P≤0.05. The comparison of continues data: vascular density of the superficial macular and peripapillary regions. In addition to the analysis of factors that affecting vascular density in these areas was statistically performed. Data were presented in form of tables and figures, where the figures done by Microsoft Excel 2016.

3.6 Ethical Considerations

This study was conducted in accordance with the principles of the Declaration of Helsinki. Ethical approval was obtained from the Ethics Committee of Benghazi Eye Hospital prior to the initiation of the research. All participants were informed about the nature, purpose, and procedures of the study, and written informed consent was obtained from each participant before their inclusion. Participants were assured of the confidentiality of their personal and medical information, and data were anonymized to ensure privacy.

4. Result

4.1 Demographics

A total of (n=60 eye) myopic patients were participate in this study after excluding the participants who did not match with the inclusion criteria, they divided to 3 groups, (20) eyes in each group divided as mild, moderate and high myopia groups. (Table I) demonstrates demographic characteristics of the participants in term of age, spherical equivalent, axial length and BCVA. There were no significant differences in age between the three groups. While, there is strong statistical significant in Spherical equivalent, Axial length and BCVA among myopia groups.

Table I: Basic demographic data of three groups of participants

Variable	Mild myopia (n=20)	Moderate myopia (n=20)	High myopia (n=20)	P. value
Age (years)	33.50±9.0230	30.10±9.2730	32.05±8.1787	0.485**
Spherical equivalent	-1.93±0.54	-4.38±0.81	-9.58±2.07	0.0001*
Axial length	23.68±0.82	24.80±1.06	26.51±1.38	0.0001*
Best corrected visual acuity	0.90±0.12	0.84±0.15	0.69±0.07	0.0001*

Numbers displayed are mean ± SD. All calculated by the one-way analysis of variance.
*Highly significant ** Non significant

Table II: The vascular density of the macula and peripapillary among three groups of the participants

Parameter	Variables	Myopia			P- value
		Mild (n=20)	Moderate(n=20)	High(n=20)	
Macular vascular density	Superior	54.12±1.31	52.87±1.31	44 5±1.46	0.0001*
	Inferior	54.15±1.24	52.78±1.27	43.90±1.54	0.0001*
	Central	19.05±1.32	18.95±1.32	18.95±1.23	0.960**
	Nasal	53.21±1.29	51.68±1.36	42.70±1.50	0.0001*
	Temporal	53.25±0.93	52.41±1.54	44.85±1.54	0.0001*
Peripapillary vascular density	Superior	48.65±1.53	49.35±2.00	43.70±2.66	0.055*
	Inferior	49.60±2.04	49.55±2.01	45.60±2.46	0.007*
	Central	18.45±1.50	19.25±1.52	18.20±1.51	0.080**
	Nasal	48.05±1.96	47±2.77	37±2.87	0.0001*
	Temporal	53±2.45	50.85±1.81	46.25±2.07	0.0001*

Numbers displayed are mean ± SD. All calculated by the one-way analysis of variance
*Highly significant ** Non significant

In the high myopia group, the density of macula superior, inferior, nasal and temporal vessels was strongly statistical significant reduction than that of the other two groups (P=0.0001). While there is no statistical significant in central vascular density of macula (p= 0.960). On the other hand, the peripapillary vessels density had statistical significant reduction more in high myopic patients, compared with other two groups which is more in nasal than the others (temporal, inferior and superior) (p =0.001, p=0.007, p=0.055) respectively. (Table II). So, there was a statistically significant difference between the groups in terms of density of all vessels of macula and peripapillary.

4.2 Correlation between spherical equivalent with macular and peripapillary vessel densities

Positive correlation were found between spherical equivalent and superior macular vessels (r = 0.766, p=0.0001). And inferior, nasal, and temporal macular vessels (r=0.815, p= 0.000), (r=0.76, p=0.0001) and (r=0.809, p=0.0001) respectively. (Figure I). While, there is no statistical correlation between spherical equivalents with superior peripapillary vessel.

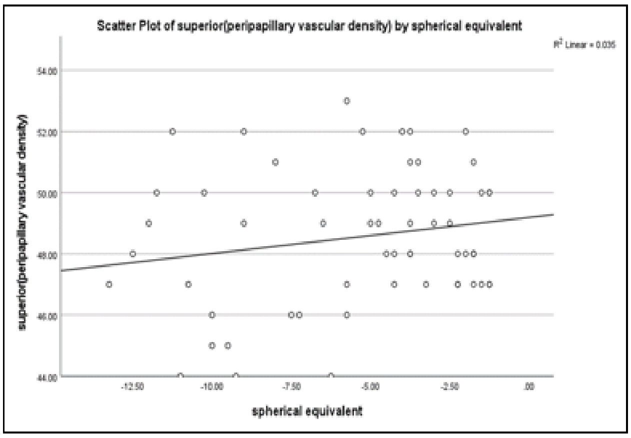

Figure I: Correlation between spherical equivalent with macular vessel densities.

The correlation between spherical equivalent and densities of Inferior peripapillary vessel (r=0.381, p=0.003), nasal peripapillary vessel (r=0.630, p=0.000) and temporal peripapillary vessel (r=0.538. p=0.000) were statistically positive. (Figure II)

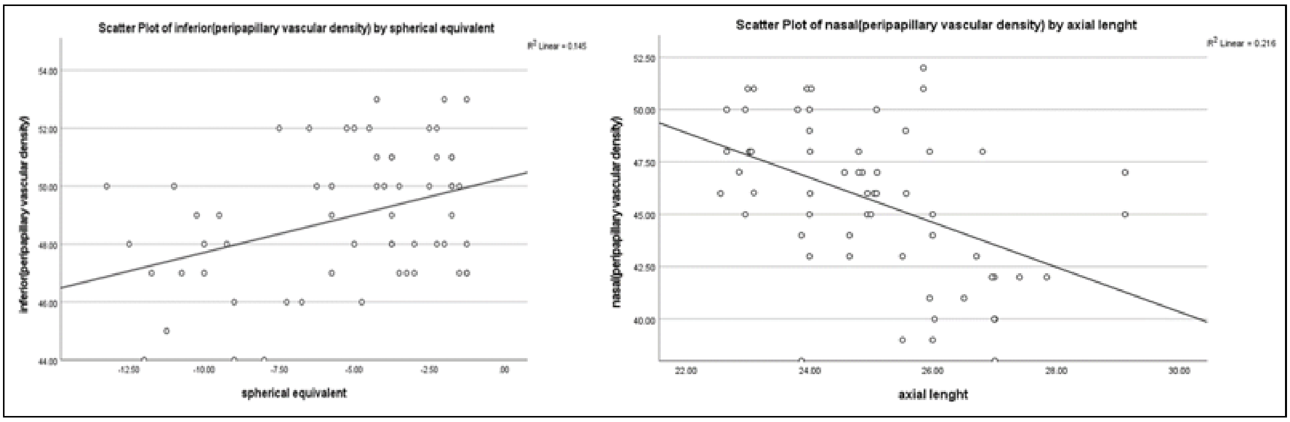

Figure II: Correlation between spherical equivalents with peripapillary vessel densities.

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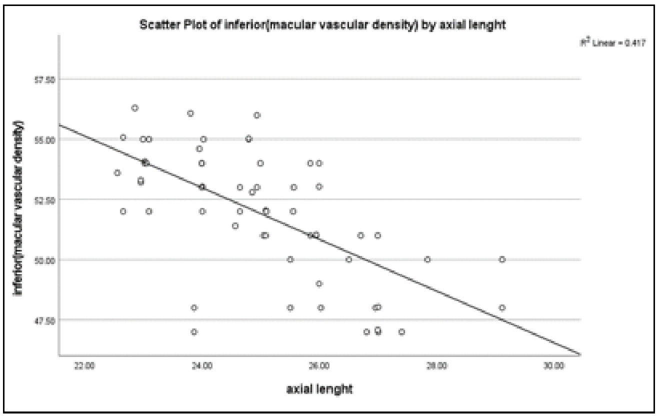

Figure III: Correlation between axial length with macular and peripapillary vessel densities:

4.3 Correlation between axial length with macular and peripapillary vessel densities

Correlations between axial length and macular and peripapillary vessel densitiesare shown in (Figure III). Among different groups of myopic eyes, there were strong significant negative correlations between axial length and inferior (r= -0.592, p=0.0001), superior (r= -0.646, p=0.000), nasal (r= -0.589, p= 0.0001), and temporal macular vessels (r= -0.690, p= 0.000). As the same as in peripapillary vessels, except for superior peripapillary vessels had no statistical correlation with the axial length (r= -0.019, p= 0.884).

5. Discussion

This study concludes that no correlation exists between age and vascular density. Other study shows that the decrease in the retinal blood supply more prominent in older peoples, especially those older than 35 years or more, possibly because the mean of the participants ages were mild myopia 33.50±9.0230, moderate myopia 30.10±9.2730, and high myopia 32.05±8.1787 years. In this study, the analysis of the densities of macular and peripapillary vessel among mid-aged adult with myopia. [12] The conclusion in this present study, there is no correlation was found between the age and vascular density. We believed that the decrease in the retinal blood supply more prominent in older peoples, especially those older than 35 years or more,[13] possibly because the mean of the participants ages were 33 years,.[14] In a previous study, [15] used OCTA to analyze participants over 35 years. They observed a significant correlation between the blood perfusion in the macular area and age. others reported a negative correlation between age and flow velocity in the vessels of participants over the age of 40 years. [16] However, a decrease in macular density was correlated with the increasing myopia severity. [17]

This is the same as in the results of the most previous studies which have also reported that macular vessel density is significantly lower in high myopic patients. However, a key finding of the current study was that there was no statistically significant difference between the three groups regarding the vascular density in the central (macular and peripapillary) vessels. [18]

The spherical equivalent increases as the vascular density in macula and peripapillary vessel decreased in the eyes without pathological myopic changes. [19] In addition, in this study found that with an increase in axial length negatively correlated with the vascular density in the macular and peripapillary areas.

This finding has been confirmed in many previous researches as well. [20] With the increase in the axial length, the retinal vascular density of the myopic eyes represents a downward trend, and a series of changes occurred in the retina. [21] A possible reason is that the arterial blood flow is different in parts of the retina. [22].

Avascular zone characterized by active local metabolism, maintaining the blood supply in a relatively stable state. Since different OCTA devices use different technologies and patients are of different ages and sexes, it is not possible to standardize measurements.[23] On the other hands researches have reported that no significant differences among various levels of myopic severity.[12,24] This is explained by segmentation of the retina in OCT-A, the exclusion criteria were employed.[14] The present research only included OCT-A scan quality of at least 50, adopted a 3 × 3 mm scanning area rather than a 6 × 6 mm area centered on the macula. OCTA was used to evaluate the macular and vascular density quantitatively. [25]

6. Conclusion

In conclusion, this study showed that the macular and peripapillary vascular densities were significantly decreased in highly myopic eyes. However, no significant correlation was found between the age and retinal vascular density and needs to be further studied. In addition, the axial length negatively correlated with the vascular density in the macular and peripapillary area. Similarly, the spherical equivalent also positively correlated with macular and peripapillary vascular density. As for quantitative evaluation of macular and parapapillary vascular density in myopia, the OCTA imaging is a practical technique helps understand the underlying mechanism of pathological changes and complications in mild, moderate and high myopia and find potential ways to manage and treat myopia development. Although further studies with large samples is needed to verify this conclusion.

Declaration of interest
The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper. No funds, grants, or other support were received.

Conflicts of interest
The authors have no conflicts of interest to declare.

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Author Profile

Sabah Saad Eldressi Professor of ophthalmology head of ophthalmology department, Benghazi university Libya