Comparison of the foveal avascular zone in unilateral amblyopic patients with the fellow eye by using optical coherence tomography angiography (oct-a)

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ABSTRACT:

Objective: To compare Foveal avascular zone of unilateral amblyopia to that of the contralateral eye in the same patients by quantifying the foveal avascular zone (FAZ) with Superficial Vascular Plexus (SVP) optical coherence tomography angiography (OCT-A).

Methodology: A retrospective review of patients diagnosed with anisometropic amblyopic was done from January 2021 to October 2022 at Department of Ophthalmology and Visual Sciences, Civil Hospital Karachi and SMBB Trauma Centre. Foveal avascular zone (FAZ) diameter was measured at horizontal and vertical axis through OCT-A. Data was entered and tabulated using SPSS 26.

Results: A comparative analysis of 60 eyes of 30 patients was done. The proportion of males to females was calculated as 2:3. Age range was from 17 to 37 years. The average vertical and horizontal FAZ diameter of SVP in normal eyes was measured to be 616.40 and 616.10 microns, whereas in amblyopic eyes, it was 618.80 and 621.30 microns, respectively.

Conclusion: There was no significant difference in the measurements in the vertical and horizontal diameter of amblyopic eyes with that of the fellow eye of the same patient, when the data was analysed in our study ($p>0.29$ and $p>0.111$ respectively).

Keywords: Dentistry practice, Diagnostic Tomography, Optical Tomography, Optical Coherence, Vision Disorders, Fovea Centralis, Limbus Cornea.

Introduction:

Amblyopia; primarily identified by decreased visual acuity, resulting from disuse caused by the lack of a clear image formed on the retina. Some abnormalities in the retina have been identified in amblyopia, such as retinal ganglion cell failure.[1-3] To date, the precise characteristics and the structural and functional relationship of retinal microvasculature involvement in amblyopia remain unclear.

In recent decades, comprehensive analyses of the retinal morphology in amblyopic eyes have been conducted through in vivo studies using Optical Coherence Tomography (OCT).[4] Optical coherence tomography angiography (OCTA) has been developed as a non-invasive diagnostic tool used to visualize the retinal microvasculature.[5] Since OCTA does not require dye infusion and can be completed quickly, it has no adverse effects and is also easy to perform, even in children. Furthermore, the area of the blood vessel can be accurately seen and the foveal avascular zone (FAZ) can be measured quantitatively. Morphological changes within the FAZ equivalent to diabetic retinopathy (DR) and retinal blood vessel occlusion (RVO) are clearly identifiable.[6,7]

Previously fluorescein angiography (FA) and Indocyanine green angiography (ICGA) were considered to be methods of choice for assessing retinal disease.[8,9] Nonetheless, there are certain limitations associated with FA and ICGA, one of which is the requirement for intravenous dye infusions.[10,11] When comparing amblyopic eyes to normal controls, several studies using OCT-A on young participants have found aberrant microvascular patterns.[12] Nonetheless, due to diverse study plans and multiple confounding factors associated with OCT-A, the findings have been inconsistent.[13] Moreover, there is difference in opinion that changes in FAZ can depict severity of amblyopia and monitor regression after treatment or not. Total Macular Vascular Density and FAZ are two parameters that have been evaluated in population of other regions. So far there is lack of studies that assessed relation between foveal vascular density of amblyopic eyes and normal eyes in Pakistani population. This research aimed to evaluate and measure the foveal avascular zone in patients with anisometropic amblyopia through OCTA scans,[14] thereby facilitating future investigations in this area and suggesting modifications and additional treatment strategies for amblyopia.

Objective:

To compare Foveal avascular zone of unilateral amblyopia to that of the contralateral eye in the same patients by quantifying the foveal avascular zone (FAZ) with Superficial Vascular Plexus (SVP) optical coherence tomography angiography (OCT-A).

Methodology:

This descriptive, comparative retrospective study was conducted involving 60 eyes from 30 patients at Department of Ophthalmology and Visual Health Sciences DUHS, SMBBTC, Dr Ruth. K. M. Pfau Civil Hospital, Karachi between January 2021 to October 2022. Consecutive convenience sampling was employed. Data was gathered of all patients with anisometropic amblyopia, who were diagnosed and had their entries made in our computerized data base.

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They were contacted, called for regular check-ups and were then examined. Informed written consent of patients was obtained of those who were willing to participate. The presence or lack of treatment history of amblyopia wasn't factored in the interpretation of data. Their best corrected vision was checked and slit lamp examination was done to exclude any other ophthalmic condition resulting in decreased visual acuity. Ethical exemption was taken from Institutional Review Board (IRB) of DUHS dated IRB-1832/DUHS/Exemption/2021/609

All measurements were done with optical coherence tomography (OCT-A) of SPECTRALIS® OCT Angiography Module. OCTA images were obtained through spectral-domain (SD) OCT with the aid of software (HEIDELBERG Eye Explorer software, VERSION-1.10.4.0). A single skilled ophthalmic technologist captured all SD-OCT images under non-mydriatic conditions within the time frame of 9:00 AM to noon. Subjects who had anisometropic amblyopia and suffered from systemic conditions, including diabetes, hypertension, or other disorders were not considered as these diseases usually adversely affect the retinal vessels. Superficial vascular layer (SVP) is now described as the vascular layer. The En-face image represents the inner retinal layer observations as the superficial retinal layer. Foveal avascular zone (FAZ) of Superficial Vascular Plexus (SVP) was quantified. Horizontal and vertical axis in amblyopic adults was measured. No interventions were performed on the patients' eyes that could influence the measurements. After the image acquisition, FAZ diameter of SVP was quantified in both vertical and horizontal meridian by manual parameter tool given in the software. The diameter taken was identified as the inner most detectable well-demarcated vascular markings in horizontal and vertical planes as shown in Fig A and Fig B.

Figure 1: Comparison of FAZ of both eyes of same patient. (A1= right normal eye, A2= left amblyopic eye)

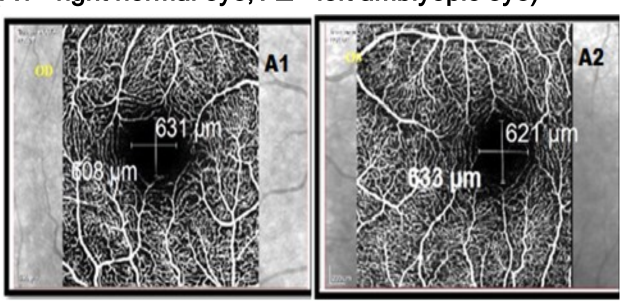
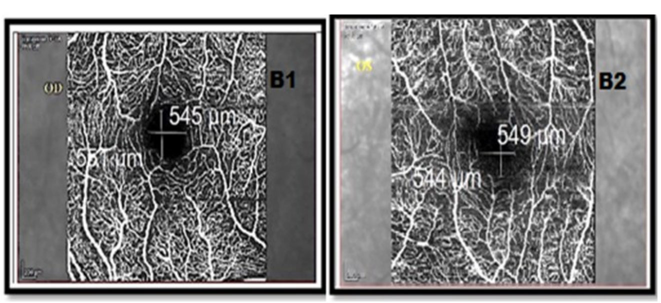


Figure 2: Comparison of FAZ of both eyes of another patient. (B1=right amblyopic eye, B2= left normal eye)



The diametric measurements of the FAZ, recorded in microns along horizontal and vertical axes, were analyzed using a paired sample t-test. Measurements were contrasted with the fellow eyes of the same amblyopic patients.

Results:

Data analysis of 60 eyes of 30 patients was done in which 18 were females and 12 were males with a proportion of 2:3. The patient's age ranged between 17-37 years; with a mean age of 25±4.56 years. The average vertical and horizontal axis of FAZ diameter of SVP in normal eyes was 616.40 and 616.10 microns respectively, while mean in vertical and horizontal axis of FAZ diameter of SVP in amblyopic eye was 618.80 and 621.30 microns respectively as tabulated in table 1.

Table No 1: Samples Statistics of Vertical and Horizontal axis of amblyopic and normal eyes.

	Mean	No	±SD
Pair 1. Normal Vertical axis	616.40	30	71.736
Amblyopic Vertical axis	616.80	30	72.578
Pair 2 Normal Horizontal axis	616.10	30	78.498
Amblyopic Horizontal	621.30	30	76.498

Table No 2: Statistical comparison between same axis of normal and amblyopic eye.

	Mean	±SD	p-value
Pair 1. Normal Vertical axis & Amblyopic Vertical axis	-2.400	6.753	0.290
Pair 2. Normal Horizontal axis & Amblyopic Horizontal	-5.200	9.319	0.111

No statistical significance was found between FAZ of SVP with age and gender ($p>0.05$). The variation between the horizontal and vertical measurement FAZ between normal and amblyopic eye was also not statistically significant as ($P= 0.111$ for horizontal and $P=0.29$ for vertical axis) which is depicted in table 2.

Discussion:

Our study showed that FAZ of SVP was not clinically correlated with age and gender. This was supported by Hsu ST et al [13] who concluded in his study amongst pediatric age that FAZ didn't vary with age or gender. Samara et al.[15] in a study examined the average diameter of FAZ in 17 eyes with branch retinal vein occlusion (BRVO) and contrasted it with that of 17 unaffected eyes. The average diameter of superficial vascular plexus of FAZ measured to be 0.312 mm2 in eyes affected with BRVO and 0.284 mm2 was recorded in non-diseased eyes ($p = 0.54$). While in other studies, Pakzad-Vaezi Kaivon et al[16] and Bringmann Andreas et al[17] reported that FAZ was either reduced in size or was completely undeveloped in preemie babies. The genesis of the FAZ is considered crucial in the progression of the foveal pit. If FAZ cease to develop, the inner retinal layers may remain in the foveal centre, resulting in a narrower foveal pit.[18] Wong ES et al[19] studied 1075 eyes in Hong Kong and tabulated that FAZ and VD (Vascular density) between amblyopic and normal eyes in the superficial vascular plexus were indistinguishable. They further found that parameters like Vascular Density Index (VDI), Foveal Density (FD) and Foveal circularity (FC) are better parameters in OCT-A for comparison between amblyopic and normal eyes. A study by Yilmaz et al.[20] and another by Lonngi et al.[21] found a reduced vessel density in both the superficial and deep capillary plexus of amblyopic eyes. Demirayak B et al.[12] conducted a study comparing amblyopic and control grouped eyes in pediatric population and reported that there was notable difference in the two groups. Likewise, a cross sectional analysis by Karabulut M et al.[22] also proved that FAZ was equivalent in both amblyopic and normal eyes as their recorded p value was 0.561. However, it has been noted that the measured values obtained from different OCTA models may vary.[23]

We found no significant difference in the FAZ diameter of the superficial vascular plexus between the amblyopic eye and contralateral normal eye. This finding contrasts with published studies that focused on either entirely healthy individuals or amblyopic eyes from various patients. However, it remains ambiguous whether the abnormal microvascularization observed in amblyopic eyes is a cause or a consequence of amblyopia, and this study does not establish a causal relationship. A decrease in the circularity of the FAZ has been identified as a reliable indicator of vascular dropout and is associated with the progression of vascular maculopathy.[24] While the precise pathophysiological mechanisms are not fully understood, the vascular changes in amblyopic eyes may serve as an early signal of alterations in retinal neuron metabolism.[25]

The limitations of this study must be recognized. We were unable to apply a specific evaluation method for distortions, such as image bevel, in our OCT-A standard control. The research included only a small sample size, primarily consisting of amblyopic patients with anisometropia, which may limit the applicability of the results to other forms of amblyopia, such as strabismic or stimulus-deprivation amblyopia. Evaluating only the foveal avascular zone (FAZ) is insufficient, and it remains uncertain whether the current optimal results are applicable to severe amblyopia. To substantiate our findings, further longitudinal studies involving a larger cohort of amblyopic patients, including those undergoing pre- and post-treatment assessments, are essential. Additionally, future research should focus on the long-term progression of abnormal vasculature, structural changes in the macula, and alterations in neuronal layers in relation to amblyopia management to enhance our understanding of the underlying pathophysiology of this condition.

Conclusion:

There was no significant difference in the measurements in the vertical and horizontal diameter of amblyopic eyes with that of the fellow eye of the same patient, ($p>0.29$ and $p>0.111$ respectively)

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- Dr Mehvash Hussain conceived, designed and did editing of the manuscript
- Dr Fizzah Farooq did data collection, statistical analysis and manuscript writing
- Jaweria Zaheer did proof read manuscript.