RESEARCH ARTICLE

Shape and size of foveal avascular zone in normal subjects using optical coherence tomography angiography (OCTA): A retrospective analysis

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Abstract

Objective: To determine the shape and size of foveal avascular zone in terms of perimeter, circularity, roundness and axial ratio using optical coherence tomography angiography.

Method: The retrospective study was conducted at the Yaqeen Vison Clinic, Lahore, in August 2023, and comprised data from January 2020 to December 2022 of patients of either gender aged 17-84 years having best corrected visual acuity ≥6/6 and normal retina. Foveal avascular zone was measured using optical coherence tomography angiography. Perimeter, circularity, axial ratio and roundness were assessed. Only one eye of each subject was considered for analysis. Data was analysed using SPSS 25.

Results: Of the 208 patients, 108(52%) were females and 100(48%) were males. The overall mean age was 56.55±16.6 years. There were 106(51%) right eyes and 102(49%) left eyes. Mean values for perimeter, circularity, axial ratio and roundness were 2.18±0.3mm, 0.93±0.12, 1.18±0.23and 8.09±1.41, respectively. There was a significant association of foveal avascular zone perimeter with age (p=0.001). Circularity, axial ratio and roundness did not have significant variations with age (p>0.05).

Conclusion: Foveal avascular zone in Pakistani individuals was found to be larger, and there was more variation in foveal avascular zone size than shape, making shape a more reliable factor in retinal vascular diseases.

Keywords: Fovea centralis, Retina, OCT, Fluorescein angiography. (JPMA 76: 863; 2026)

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Introduction

Foveal avascular zone (FAZ) is an important landmark of retina, which is affected in different retinal vascular diseases. The size and shape of FAZ is disrupted in cases of disturbed macular perfusion, which is investigated by fundus fluorescein angiography (FFA). However, the use of intravenous dye in FFA is one of the greatest drawbacks, which is now overcome by optical coherence tomography angiography (OCTA), which determines the size of FAZ more accurately than FFA.[1] There is a large variability in FAZ size in normal population, making it a less reliable factor in treating and keep track of disease progression.[2] FAZ shape shows less variability in normal individuals, while perimeter, axial ratio and circularity of FAZ are some of the shape parameters to investigate retinal pathologies.[3,4]

FAZ has also shown variation with age, gender, refractive errors and even ethnicity.[5,6] To differentiate normal FAZ from any abnormality seen in retinal diseases, it is imperative to know the variation in size and shape in normal healthy population. To our knowledge, there is no data available on the size and shape of FAZ in healthy Pakistani population. The current study was planned to fill the gap in literature by measuring the size and shape of FAZ using OCTA in a tertiary care setting.

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Materials and Methods

The retrospective study was conducted at Yaqeen Vison Clinic, Lahore, in August 2023, and comprised OCTA charts from January 2020 to December 2022, after approval from the ethics review committee of the Lahore General Hospital, Lahore. Informed consent had been taken from the participants before OCTA.

Data was included related to patients of either gender aged 17-84 years, having best corrected visual acuity (BCVA) ≥6/6 and normal retina on dilated fundus examination and OCT. Patients with history of any ocular or systemic disease, previous ocular surgery/intraocular injection, high refractive errors of >6.0 dioptres, poor signal strength and images with artifacts were excluded.

To standardise the images, all images had been taken with Swept Source OCT (Topcon Triton, Oakland, New Jersey, USA), with a scan area of 3×3mm, and inform segmentation settings. The images had been taken by two independent well-trained operators to minimise artifacts. The images with disagreement between the two observers were excluded. Signal strength had been kept at signal-to-noise ratio (SNR).[5] As deep plexus has lesser defined borders, superficial plexus was used. FAZ was assessed using perimeter, circularity, axial ratio and roundness. A distance

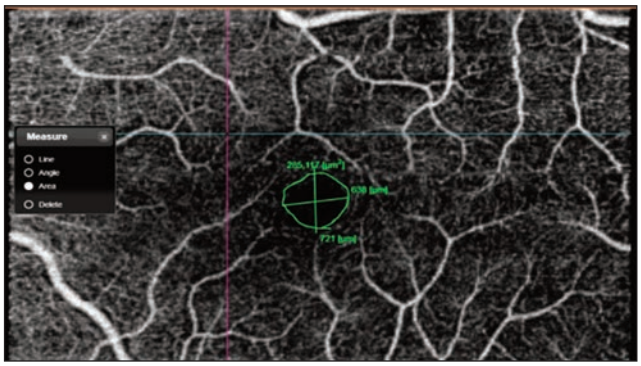

Figure: An optical coherence tomography angiography (OCTA) image showing superficial retinal plexus with foveal avascular zone (FAZ) outlined manually.

of 3µm beneath the internal limiting membrane was taken as the upper border, and the lower margin was 15µm below the inner plexiform layer. After acquiring images, FAZ was outlined manually by two researchers independently, while area and perimeter were automatically calculated (Figure).

Standard formulas were used for circularity (C), axial ratio (AR) and roundness (R) on the basis of area (A), perimeter (P), length of minor axis (LmA) and length of major axis (LMA):[7] $C=4\pi \times A/P^2$; AR = LMA/LmA; $R=4\pi \times A/(LMA)^2$.

The circularity index was defined as deviation relative to a perfect circle. Value of 1.0 indicated perfect circle. The lower the value, lesser was the shape circular. Only one eye of each subject was considered for analysis.

Data was organized using Excel sheet and analysed using SPSS 25. Shapiro-Wilk test was used to check data normality. Quantitative variables were presented as mean±standard deviation. Pearson's coefficient was used for correlation analysis. Correlation coefficient <0.19 was considered very weak, 0.2-0.39 as weak, 0.4-0.59 as moderate, 0.6-0.79 as strong, and 0.8-1.0 as very strong. P<0.05 was considered significant.

Results

Of the 208 patients, 108(52%) were females and 100(48%) were males. The overall mean age was 56.55±16.6 years (range: 17-84 years). There were 106(51%) right eyes and 102(49%) left eyes. Mean values for perimeter, circularity, axial ratio and roundness were 2.18±0.3mm (range: 1.4-2.99mm), 0.93±0.12 (range: 0.12-1.35), 1.18±0.23 (range: 0.73-2.82) and 8.09±1.41 (range: 1.026-11.85), respectively. Data was grouped according to these variables (Table 1).

There was a significant association of foveal avascular zone perimeter with age (p=0.001). Circularity (p=0.628), axial ratio (p=0.940) and roundness (p=0.653) did not have significant variations with age. The correlation coefficient was r=0.098 for perimeter, r=0.068 for circularity, r=0.022 for axial ratio and r=0.057 for roundness. Inter-item correlation (Table 2) and covariation matrix (Table 3) were also worked out.

Table-1: Distribution of study variables.

	n (%)
Age Groups (years)	
< 20	6 (2.90
21-40	31 (14.9)
41-60	71 (34.1)
61-80	96 (46.2)
> 80	4 (1.9)
Total	208 (100)
Perimeter (µm)	
1400 -1850	37 (17.8)
1851-2200	79 (38.0)
2201-2650	68 (32.7)
2651-3000	24 (11.5)
Total	208 (100)
Circularity	
0.120-0.420	2 (1.0)
0.421-0.720	2 (1.0)
0.721-1.02	166 (79.8)
1.021-1.35	38 (18.3)
Total	208 (100)
Axial Ratio	
0.731-1.230	157 (75.5)
1.231-1.730	46 (22.1)
1.731-2.230	3 (1.4)
2.231-2.820	2 (1.0)
Total	208 (100)
Roundness	
1.026-3.726	2 (1.0)
3.727-6.426	18 (8.7)
6.427-9.126	148 (71.2)
9.127-11.850	40 (19.2)
Total	208 (100)

Table-2: Correlation of age with perimeter, circularity, axial ratio and roundness.

	Age (years)	**Perimeter (µm)**	**Circularity**	**Axial ratio**	**Roundness**
Age (years)	1.000	0.098	0.068	0.022	0.057
Perimeter	0.098	1.000	-0.112	-0.208	0.044
Circularity	0.068	-0.112	1.000	0.118	0.665
Axial ratio	0.022	-0.208	0.118	1.000	-0.606
Roundness	0.057	0.044	0.665	-0.606	1.000

Table-3: Covariation of age, perimeter, circularity, axial ratio and roundness.

	Age (years)	**Perimeter (µm)**	**Circularity**	**Axial ratio**	**Roundness**
Age (years)	275.688	564.007	0.137	0.082	1.330
Perimeter	564.007	121345.711	-4.745	-16.398	21.469
Circularity	0.137	-4.745	0.015	0.003	0.114
Axial ratio	0.082	-16.398	0.003	0.051	-0.194
Roundness	1.330	21.469	0.114	-0.194	1.991

Discussion

The current study showed that the correlation and covariance matrices provided valuable insights into the relationships between age and various lesion characteristics, including perimeter, circularity, axial ratio and roundness. The correlation matrix highlighted the strength and direction of these relationships, revealing that age had minimal impact on lesion shape, while some shape features, like circularity and roundness, were strongly interrelated. The covariance matrix supported these findings by showing a notable covariation between age and perimeter, suggesting that lesion size may increase slightly with age, while most other variables exhibited low covariance, indicating they varied independently. Overall, the findings helped identify patterns in lesion morphology that may have clinical relevance, particularly in understanding lesion growth and shape characteristics.

In the current study, a weak positive correlation was observed between age and perimeter (r=0.098), and similarly weak associations with other shape descriptors. It is important to highlight that a statistically significant but weak correlation may lack clinical importance.

In a study[7] FAZ perimeter was 0.18mm, circularity was 0.08, axial ratio was 0.09 and roundness was 0.08. These values were higher in the current study. This difference can be a variation caused by manual marking of FAZ or ethnic variation.

In terms of ethnicity, the current results are consistent with an earlier study,[8] according to which, Asian and Hispanics had significantly larger FAZ than Whites.[8]

When FAZ was measured with FFA, variation in size of FAZ with increasing age was reported.[9] Other authors found no correlation of age with FAZ.[10,11] Such discrepancies could be attributed to different study populations or to subjectivity caused by measurement.

In terms of FAZ shape, the current results showed statistically non-significant variation. However, studies have shown that in diabetic patients, shape and circularity of FAZ differed significantly than the normal.[12,13] This makes FAZ shape an important sign of disease process.

Variation in results could also be owing to the effect of the type of OCTA machine used to measure FAZ. Literature shows that circularity and axial ratio were affected by the device used to measure these values.[14,15] This shows that there must be some standard protocol to measure FAZ parameters.

The current study determined FAZ shape in terms of circularity, axial ratio and roundness. In another study, the shape was described as horizontally oval (39%), round (29.3%), pentagon (17.1%), vertically oval (7.3%), and non-specific (7.3%).[16]

Considering the association of FAZ size with age, it has been reported that in the paediatric population, FAZ decreases with increasing age, while it increases with increasing age in adults.[17] Although, paediatric population was not included in the current study, the results correlate with respect to variability of FAZ with increasing age.

It is well documented that FAZ size shows normal variations with axial length and refractive error of the eye.[2,4-6] However, a study showed that shape parameters, like circularity index and axis ratio, did not require axial length corrections, making them better disease markers.[18] For example, in diabetic retinopathy, capillary occlusion and other haemodynamic disturbances can lead to change in FAZ shape irrespective of the axial length. In glaucoma, such changes in FAZ were reversible with glaucoma surgery.[19]

Literature also shows that thin fovea is associated with larger FAZ and more circular shape, and thick fovea is associated with small FAZ and irregular shape. This could be one of the reasons of different FAZ sizes among different ethnicities.[20] These findings endorse the idea that normative data must be available from the Pakistani population to address this variation.

Although the study was the first of its kind from Pakistan, it has several limitations, like include different strengths of the age groups, which could have affected the regression model. The study did not consider axial length of eyes, central macular thickness, choroidal thickness and deeper retinal plexuses. As all the normal OCTA reports from January 2020 to December 2022 were included, no sample size was calculated.

Conclusion

Variation in the size and shape of different populations is important to facilitate diagnosis and prognosis of retinal vascular diseases affecting FAZ. However, as there is more variation in FAZ size than shape, circularity, axial ratio and roundness appeared to be more reliable factors to be considered in the analysis of FAZ in retinal vascular diseases.

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Conflict of Interest: None.

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Author Contribution:

AC: Literature search, writing, drafting, data collection and questionnaire design.
MM: Design, concept, critical and statistical analysis.
TGM: Data analysis, critical review and data interpretation.
MA: Data collection and compilation.
AI & AM: Data collection.