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Original Research Article

# Branching Pattern of Central Artery of Retina on the Optic Disc

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## ABSTRACT

**Background:** The central artery of retina (CRA), on reaching the optic disc, divides into two branches of the first order - superior and inferior. Each of these divides into two branches of the second order – temporal and nasal. Emergence of CRA on the optic disc and further sequence division is not constant. Anomalies in the branching pattern of CRA may be associated with certain optic disc abnormalities like optic disc drusen, optic disc pits, or colobomas. The objectives of the study are: 1) To identify the variations in the number of branches of CRA emerging on the optic disc, 2) to study the variations in the number of branches arising from the main trunk on the optic disc, and 3) to study the variations in the shape of branching pattern of CRA on the optic disc.

**Methodology:** This observational study was carried out at AIIMS, Guwahati, with the approval of the IEC. Sample size is 160 subjects with 320 fundus images. Subjects with diabetes, hypertension, and other vascular diseases are excluded. The fundus examination was carried out with a fundus camera, and digital photographs were taken. Then the images are magnified to get a clear picture of the optic disc. Images are analyzed by two observers.

**Results:** In the present study, the CRA emerged on the optic disc as one (82.8%), two (13.1%), and three (4%) branches. Number of first-degree branches observed on the optic disc is two – superior and inferior (74.7%), three – superior, inferior, and nasal (10.9%), superior, inferior, and macular (8.3%), and four – superior, inferior, nasal, and macular (6%). The shape of branching patterns of the central artery on the optic disc observed are X-shape type I (52.5%), X-shape type II (7.5%), X-shape type III (8.1%), Y-shape (10%), inverted Y-shape (8.1%), double V-shape (7.5%), inverted V-shape (4%), and Zeta-shape (2.1%).

**Conclusion:** Knowledge of the typical branching pattern of the central artery of retina can aid in interpreting diagnostic imaging studies such as fundus photography, fluorescein angiography, indocyanine green (ICG) angiography, fundus autofluorescence, optical coherence tomography, and retinal vascular imaging. It can help in identifying landmarks and interpreting images accurately for diagnostic purposes.

**KEY WORDS:** Central Artery of Retina, Branching, Optic Disc, Variation.

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## INTRODUCTION

The retina is the sensory layer that lines the inner surface of the back of the eyeball, where light rays are converted into neural signals for interpretation by the brain [1].

The inner two-thirds of the retina is supplied by the central artery, which is a branch of the ophthalmic artery, and the choriocapillaris supplies the outer one-third of the retina [2].

The main trunk of the central artery of retina

(CRA), on reaching the optic disc, divides into two first-order branches – superior and inferior. Sometimes additional branches, nasal and macular, may arise from the main trunk on the optic disc. Each first-order branch divides into two second-order branches - temporal and nasal, which supply blood to the four quadrants of the retina [3,4]. Each of these four major branches supplies a sector of the retina between which there is no overlap, i.e., they are functional end-arteries [2]. Temporal branches are more visible during ophthalmoscopy and curve around the macula. The nasal branches are more difficult to see since they run diagonally and in the opposite direction from the temporal branches [5].

Retinal vascular pattern is considered a highly accurate and non-forgible biometric authentication system for person identification [6,7]. CRA is narrow at the points where it pierces the dural sheath of the optic nerve and lamina cribrosa, and at these points, central retinal artery occlusion (CRAO) occurs [8-10].

Variations in the number of main trunks (as a single trunk or two or more branches) emerging on the optic disc can affect the retinal blood supply. Specific branching configurations may influence hemodynamic flow and predispose to ischemic events [3].

Familiarity with variant vascular anatomy enhances diagnostic precision and aids in early detection of pathological changes [11].

The objectives of the present study are 1) To identify the variations in the number of branches of central artery of retina emerging on the optic disc, 2) to study the variations in the number of branches arising from the main trunk on the optic disc, and 3) to study the variations in the shape of branching pattern of central artery of retina on the optic disc.

## METHODS

This observational study was carried out at All India Institute of Medical Sciences, Guwahati, with the approval of the Institutional Ethics Committee (M5/F144/2024 dated May 31, 2024). The study included 160 subjects (320 fundus images) attending the OPD at AIIMS Guwahati. Informed consent was obtained from the participants. Apparently healthy individuals without any ophthalmic abnormalities were included. Subjects with diabetes, hypertension, and other vascular diseases are excluded. The fundus examination was carried out with a fundus camera (Zeiss Clarus 700, CL700-73719), and digital photographs were taken. Then the images are magnified to get a clear picture of the optic disc and retinal vessels. Images are analyzed by two observers. Digital fundus images were added to the Canva photo editor, where the branching pattern of CRA was manually traced to facilitate anatomical assessment. The arteries are distinguished from veins, considering that veins are thicker than arteries, veins are darker (redder), and the central reflex is more recognizable for arteries [1] (Fig. 1). Data were represented as a percentage.

## RESULTS

The branching pattern of CRA on the optic disc was studied in 320 fundus images. Based on the number of branches of CRA emerging on the optic disc, five patterns were observed in the present study (Table 1 & Fig. 2).

The main trunk of CRA on reaching the optic disc divided into a) two first-order branches superior and inferior in 198 (74.7%) cases, b) three first-order branches – superior, inferior and nasal in 29 (10.9%) cases, c) three first-order branches – superior, inferior and macular in 22 (8.3%) cases, and d) four first-order branches – superior, inferior, nasal and macular in 16 (6%) cases (Fig. 3).

The shape of the branching pattern of the main trunk of CRA on the optic disc was tabulated in Table 2 & Fig. 4.

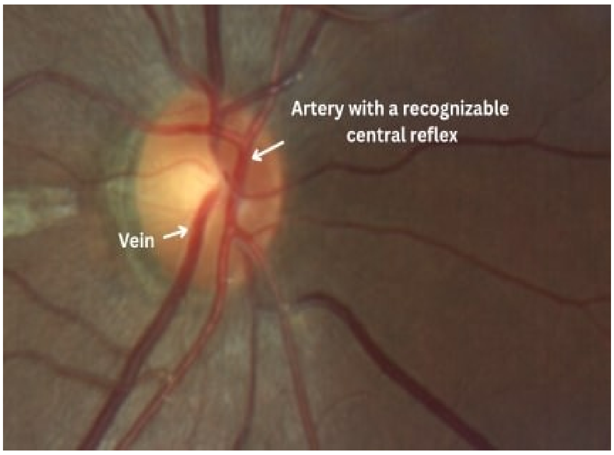


**Fig. 1:** Central artery of retina & vein

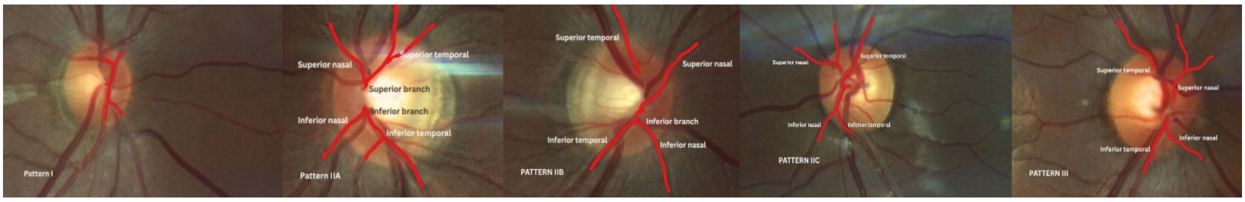


**Fig. 2:** Number of branches of CRA emerging on the optic disc.

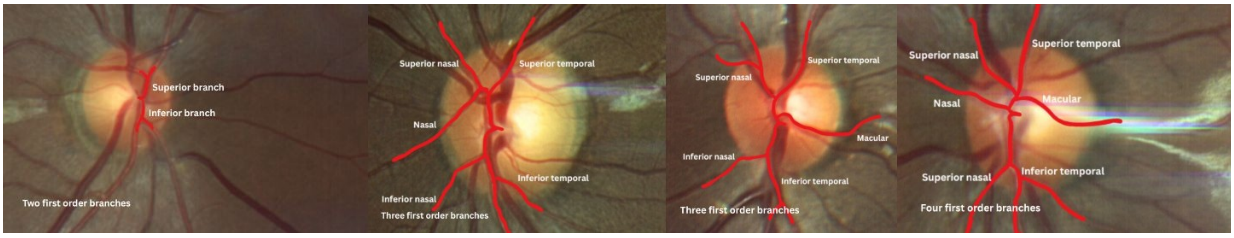


**Fig. 3:** Number of first-order branches of CRA on the optic disc.

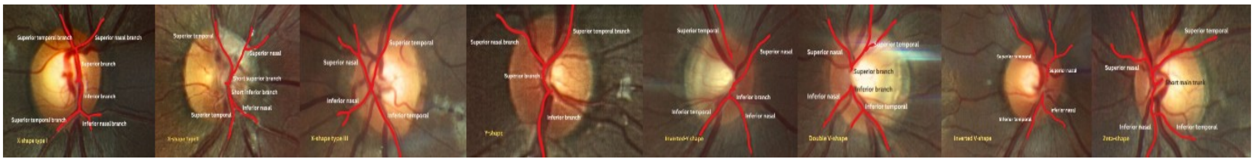

**Fig. 4:** Shape of branching pattern of CRA on the optic disc.

**Table 1:** Number of branches of CRA emerging on the optic disc.

| Pattern | No. of branches emerging on the optic disc | Description | n=320 (Percentage) |
|---|---|---|---|
| I | One | Main trunk pierced the lamina cribrosa and divided into superior, inferior or more branches | 265 (82.8%) |
| IIA | Two | Superior and inferior branches pierced lamina cribrosa separately | 24 (7.5%) |
| IIB | Two | Main trunk (giving rise to SN, IN and IT) and superior temporal branches pierced lamina cribrosa separately | 13 (4%) |
| IIC | Two | Main trunk (giving rise to ST, IN and IT) and superior nasal branches pierced lamina cribrosa separately | 5 (1.5%) |
| III | Three | Inferior (giving rise to IN and IT), superior nasal and superior temporal branches pierced lamina cribrosa separately | 13 (4%) |

(SN – superior nasal, ST – superior temporal, IN – inferior nasal, IT – inferior temporal)

**Table 2:** Shape of branching pattern of main trunk of central artery of retina.

| Shape of branching pattern of CRA | Description | n=320 (Percentage) |
|---|---|---|
| X-shape type I | Main trunk of CRA pierces lamina cribrosa and divided into long branches of first order | 168 (52.5%) |
| X-shape type II | Main trunk of CRA pierces lamina cribrosa and divided into very short branches of first order | 24 (7.5%) |
| X-shape type III | Main trunk of CRA pierces lamina cribrosa and immediately divided into branches of second order. First order branches are almost absent | 26 (8.1%) |
| Y-shape | Superior branch is short and divided into two second order branches. Inferior branch is long and after crossing the optic disc divides into second order branches | 32 (10%) |
| Inverted Y-shape | Inferior branch is short and divided into two second order branches. Superior branch is long and after crossing the optic disc divides into second order branches | 26 (8.1%) |
| Double V-shape | Superior and inferior branches pierce the lamina cribrosa separately and immediately divided into two second order branches | 24 (7.5%) |
| Inverted V-shape | Inferior branch pierces the lamina cribrosa and immediately divided into two second order branches | 13 (4%) |
| Zeta-shape | Main trunk pierces the lamina cribrosa and divides into two first order branches at a certain distance from lamina. Short main trunk is visible on the optic disc | 7 (2.1%) |

## DISCUSSION

The central artery of the retina enters the eye through the optic nerve and emerges on the optic disc, where it divides into branches essential for retinal perfusion. The morphological pattern of this branching pattern has implications in both normal physiology and various retinal pathologies.

CRA, on reaching the optic disc, typically divides into superior and inferior branches, each of which further divides into temporal and nasal branches. These branches radiate outward in a roughly four-quadrant distribution: superior temporal, superior nasal, inferior temporal, and inferior nasal. This dichotomous branching provides a segmental supply to retinal quadrants, with minimal overlap, making each region vulnerable to localized vascular occlusion. Variations in the number of branches emerging on the optic disc and atypical branching patterns might alter the expected visual field defect in central retinal artery occlusion (CRAO) or branch retinal artery occlusion (BRAO) [10,12].

This study was carried out following the classification proposed by Orlova et al [5] on the of branching patterns of CRA on the optic disc. They studied 402 fundus images and described that the central retinal artery goes out to the optic disc as one trunk (86.8%), two (13.0%), or three (0.2%) branches of the first order. The variations in the number of branches of CRA emerging on the optic disc observed in the present study are similar to the findings of Orlova et al [5]. Rishi et al described four cases of hemi-central retinal artery occlusion in young adults where CRA bifurcated behind the lamina cribrosa and emerged on the optic disc as superior and inferior branches [13].

In the present study, the main trunk of CRA on reaching the optic disc divided into two first-order branches superior and inferior (74.7%), three first-order branches – superior, inferior and nasal (10.9%), three first-order branches – superior, inferior and macular (8.3%), and d) four first-order branches – superior, inferior, nasal and macular (6%) cases. Orlova et al [5] observed two first-order branches superior and inferior (73.1%), three first-order branches – superior, inferior and nasal (20%), three first-order branches – superior, inferior and macular (3.3%), and d) four first-order branches – superior, inferior, nasal and macular (1.7%) cases. Ewis et al [14] found that the retinal end of the CRA appeared on the optic disc as a single arterial trunk and divided into two branches in 80% and into three branches in 17%. Awan et al, examining 2100 eyes, reported a single branching artery supplying the temporal half of the retina in 19 eyes and a single artery supplying the nasal half of the retina in 5 eyes [15]. In the present study, a single-branch artery supplying the temporal half or the nasal half of the retina is not observed.

In the present study, shape of branching pattern of CRA on the optic disc was observed as X-shape type I (main trunk of CRA pierces lamina cribrosa and divided into long branches of first order) in 52.5%, X-shape type II (main trunk of CRA pierces lamina cribrosa and divided into very short branches of first order) in 7.5%, X-shape type III (main trunk of CRA pierces lamina cribrosa and immediately divided into branches of second order) in 8.1%, Y-shape (superior branch is short and divided into two second order branches. Inferior branch is long and after crossing the optic disc divides into second order branches) in 10%, inverted Y-shape (inferior branch is short and divided into two second order branches. Superior branch is long and after crossing the optic disc divides into second order branches) in 8.1%, double V-shape (superior and inferior branches pierce the lamina cribrosa separately and immediately divided into two second order branches) in 7.5%, inverted V-shape (inferior branch pierces the lamina cribrosa and immediately divided into two second order branches) in 4%, and Zeta-shape (main trunk pierces the lamina cribrosa and divides into two first order branches at a certain distance from lamina. Short main trunk is visible on the optic disc) in 2.1%. Orlova et al [5] observed X-shaped I (41.3%), II (7.7%), and III type (10.2%), Y-shaped (9.4%), zeta-shaped pattern (23.7%), and V-shaped (7.7%) patterns on the optic disc. In the present study, inverted

Y-shape and inverted V-shape were observed in addition.

## CONCLUSION

The branching pattern of the central artery of the retina on the optic disc is a vital anatomical and clinical landmark. While a bifurcating pattern of the central artery of retina on the optic disc is commonly observed, individual variations are not uncommon and must be considered during clinical evaluation for diagnosing and managing retinal vascular disorders. It aids in interpreting fundus photography, fluorescein angiography, indocyanine green (ICG) angiography, fundus autofluorescence, optical coherence tomography, and retinal vascular imaging, optical coherence tomography angiography (OCTA), and in planning retinal surgeries and laser photocoagulation.

## ABBREVIATIONS

**CRA –** Central artery of retina
**CRAO –** Central retinal artery occlusion
**BRAO –** Branch retinal artery occlusion
**SN –** Superior nasal
**ST –** Superior temporal
**IN –** Inferior nasal
**IT –** Inferior temporal

## Author Contributions

**Muralidhar Reddy Sangam:** Conception and design, acquisition of data, analysis and interpretation of data, drafting the manuscript.

**Swatishree Nayak:** acquisition of data, interpretation of data, and revising the manuscript.

## Conflicts of Interests: None

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