
UNIT 6 ANATOMY OF OPTIC NERVE AND THE VISUAL PATHWAY

Structure

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6.0 OBJECTIVES

After going through this unit, you should be able to understand :

- o the anatomy of visual pathway which includes optic nerve and its connection to brain; and
- o arrangement of fibres in visual pathway.

6.1 INTRODUCTION

In previous units you have studied the structures of the coats of the **eyeball** that form image of visual object on retina. At retina level, the **image** is converted into a **form** that is transmitted to visual cortex. Eye functions only as a sense organ, what we see is by brain (visual cortex). In this unit, you will study the **anatomy** of the pathway that transmits vision from retina to visual cortex.

6.2 PARTS OF VISUAL PATHWAYS

Main function of eye is to see the external objects, This function is known as visual function. In the complex **mechanism** of this function eye focuses the image of the external object on the retina. From the retina impulse passes through the optic nerve into the brain. These are numerous relay centres through which visual impulse passes into the visual cortex, **which** is situated at the posterior part of the brain called occipital cortex. In this until we will discuss the anatomy of optic nerve, the visual pathway.

Parts of visual pathway may be **divided** at **6** levels. These include:

- 1) Optic nerve
- 2) Optic **chiasma**
- 3) Optic tract

- 4) Lateral Geniculate body
- 5) Optic radiation
- 6) Visual cortex

6.3 OPTIC NERVE

Optic nerve is formed by the axons of ganglion cells present in the retina. All the axons of the ganglion cells converge on the posterior pole of the eye and get exit from the eyeball as optic nerve.

Parts of the optic nerve are:

- 1) Intra-ocular part
- 2) Intra-orbital part
- 3) Intra-canalicular part
- 4) Intra-cranial part

Intra-ocular Optic Nerve

Extention: Extends from the anterior surface in contact with vitreous to a plane corresponding to the posterior scleral surface.

Length: 1 mm.

Scleral Canal: Opening in the sclera through which optic nerve passes is called scleral canal.

Distribution of optic nerve fibre within the retina:

Nasal Retina: Fibres from nasal retina are situated medially.

Temporal Retina: Fibres from temporal retina are situated temporally.

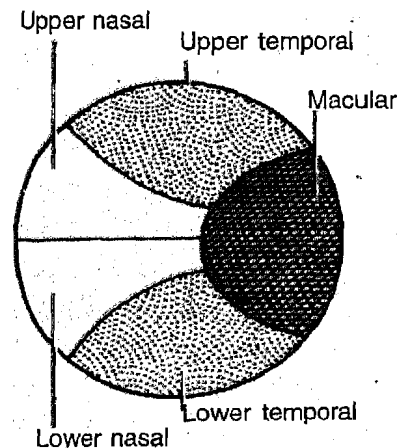


Fig. 6.1: Arrangement of fibres in the distal region (behind the eyeball) of optic nerve

Macular fibres: Placed laterally in the nerve.

Lamina Cribrosa: It is a specialized part of sclera through which optic nerve fibres pass from the eye. It contains multiple opening for the optic nerve fibres to pass. It has no definite posterior border and is continuous with the outer coat of the eyeball. Near the posterior edge of the lamina cribrosa, optic nerve gets its myelination.

Optic Disc: The part of the optic nerve seen by ophthalmoscope is called disc. At the centre of the optic disc there is depression which is called cup of the disc.

Shape of optic disc: Usually oval, vertical diameter is more than horizontal diameter.

Size of optic disc: Mean 2.69 ± 0.7 mm

- **Colour of the optic disc:** Pink, due to rich capillary network over the disc surface.

Size of optic cup in relation to optic disc: It is highly variable. On an average cup disc ratio is 0.3 to 0.4.

- **Shape of cup:** Usually funnel shape, but may be variable.

Neuro-retinal Rim: Part of the optic nerve between margin of the cup and margin of optic disc. It contains nerve axons. It is broadest in the lower segment of the disc, then above, then nasally and then temporally.

Intra-orbital Part of Optic Nerve

Definition: Part of the optic nerve within the orbit.

Length: 30 mm.

Course: Two curvatures are present during the course of optic nerve within the orbit.

Covering: Optic nerve is covered by 3 covering. These layers include from inner to outer:

- 1) Pia layer
- 2) Arachnoid layer
- 3) Dural layer

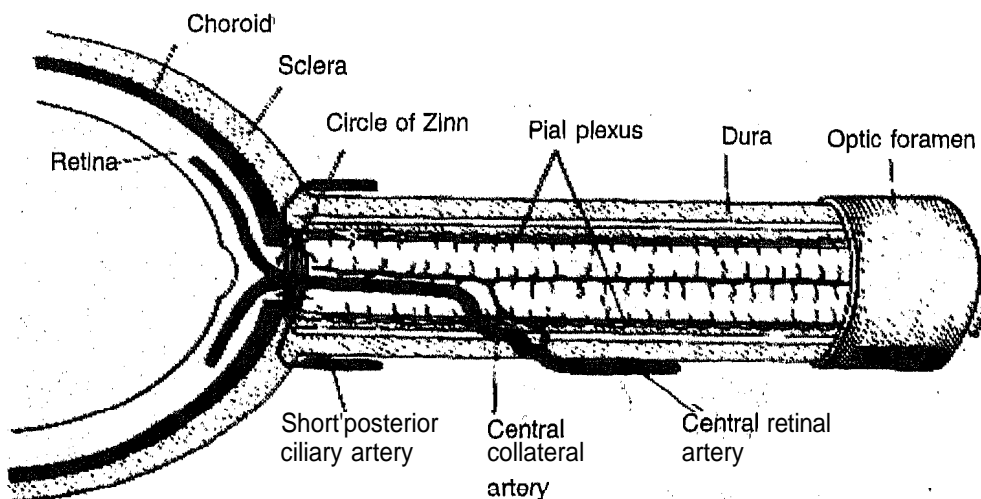


Fig. 6.2: Section of optic nerve

These layers posteriorly continue as meninges of brain.

Relationship: At the optic foramen, the optic nerve is surrounded by the origin of extra-ocular muscles. At the optic foramen, the nerve is surrounded by annulus of Zinn, a tendinous ring present at the superior orbital fissure.

The superior and medial rectus muscle sheath is closely adherent to the layers of the optic nerve.

Intra-canalicular Optic Nerve

Definition: Part of the optic nerve situated within the optic canal is called intra-canalicular optic nerve. This is the 3rd part of optic nerve.

Length: 6 mm

Situation: Within the optic canal.

Covering

- Dura mater forms the periosteal lining of the bone.
- Arachnoid mater forms the middle covering. The space below the subarachnoid space is continuous with the subarachnoid space of brain.
- Pia forms the inner most layer of optic nerve.

Intra-cranial Part of Optic Nerve

Definition: Part of the optic nerve within the cranial cavity.

Length: 10 mm

Extention: From the intra-cranial opening of the optic canal to the optic chiasma (Details of optic chiasma discussed at a later part of this unit.)

Relationship: Medial to the olfactory tract. Internal carotid artery first below and then lateral to the nerve.

Blood Supply of Optic Nerve

Central Retinal Artery

- A branch of ophthalmic artery.
- Situation: Within the optic nerve at its centre.
- Entry into optic nerve: Central retinal artery enters the optic nerve about 10 mm behind the globe.

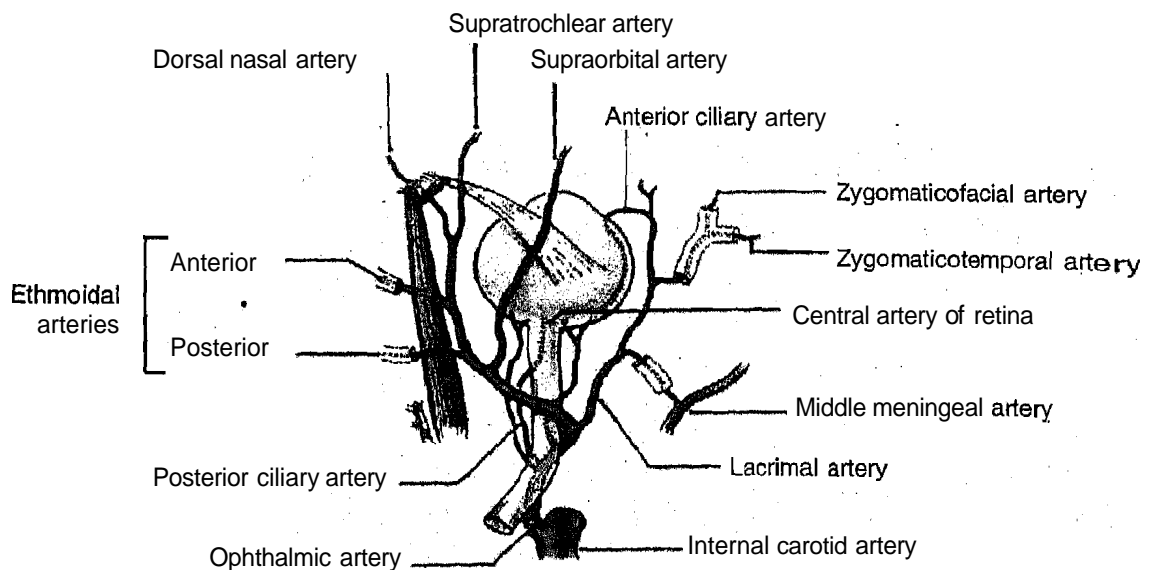


Fig. 6.3: Arterial supply

Venous Drainage of the Optic Nerve

Chiefly drains into central retinal vein.

Central retinal vein drain into ophthalmic vein.

Ultimately ophthalmic vein drains into cavernous sinus.

Check Your Progress 1

1) Optic nerve fibres are axons of which cells?

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2) Mention different parts of optic nerve.

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3) What is the 1st order neuron in the visual pathway?

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4) Visual fibres ultimately drain in to which part of brain.

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6.4 OPTIC CHIASMA

Optic chiasma is formed by union of the two optic nerves. It acts like a crossing where certain nerve fibres cross to other side and some pass uncrossed to the optic tracts.

Shape: Like a flattened band.

Situation: **Near** the anterior wall of 3rd ventricle between two thalami. Nearly in 80 per cent of cases pituitary fossa containing pituitary gland is situated below and anteriorly to the chiasm.

Dimensions

Transverse: 12 mm.

Thickness: 3-5 mm.

Orientation of Nerve Fibres with in the Chiasma

In optic chiasma, the nasal retinal fibres cross to the opposite side. The temporal retinal fibres do not cross to the opposite side. So when damage occur to the optic chiasma, the nasal retinal fibres of both sides are damaged. But fibres of temporal retinal fibres are spared. Classically, fibres which cross to the opposite side is described as crossed fibres and which does not cross to the opposite side is known as uncrossed fibres.

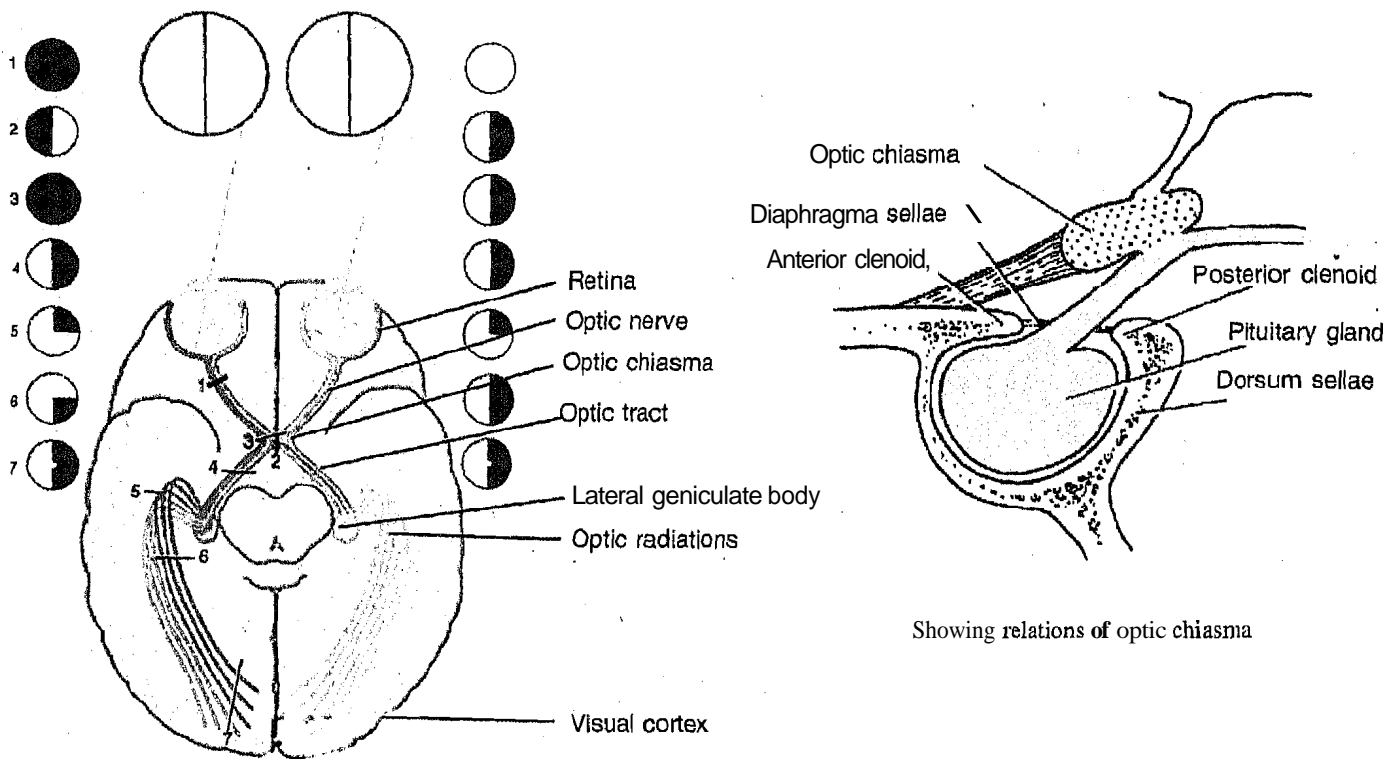


Fig. 6.4: Gross anatomy of the visual pathways

6.5 OPTIC TRACT

The optic chiasma ends into two optic tract. It starts at the postero-lateral angle of chiasma. Each optic chiasma contains nasal fibres from the opposite side and temporal fibres of the same side.

Shape: Flattened cylindrical band.

Direction: Postero-laterally optic tract reach the optic thalamus and break into 2 roots:

- 1) Medial root
- 2) Lateral root.

Medial root: Smaller than lateral root and terminates in medial geniculate body.

Lateral root: Ends in the lateral geniculate body.

Fibres ending at the medial geniculate body does not have my visual fibres. Fibres ending at the lateral geniculate body contain visual fibres. Some fibres from the lateral root do not go the lateral geniculate body and reach the pretectal nucleus. These fibres help in the pupillary reflexes--direct and consensual pupillary reflexes.

The fibres of the optic tract reach 4 major destinations:

- 1) Lateral geniculate nucleus: Reach the visual cortex:
- 2) Pre-tectal nucleus: Reach the visual cortex.
- 3) Superior colliculus: For reflex responses to light.
- 4) Nucleus of the optic tract and nuclei of the supraoptic pathway: Concerned with the optokinetic reflex.

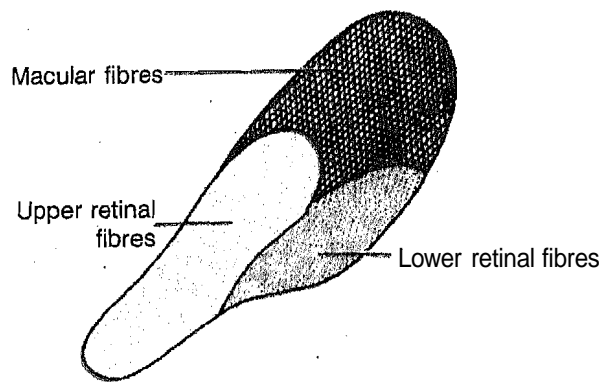


Fig. 6.5: Arrangement of fibres in the optic tract

Orientation of nerve fibres within optic tract:

Macular Fibres: Dorsolateral position.

Upper Retinal Fibres: Medial nerve of optic tract.

Lower Retinal Fibres: Lateral aspect of globe.

Blood Supply of Optic Tract

Blood supply is mainly by pial plexus formed by anterior choroidal artery and posterior communicating artery.

6.6 LATERAL GENICULATE NUCLEUS

Location: Posterolateral aspect of mid brain as an elevation.

Relay Station of Visual Pathway: Optic nerve fibres which are axons of ganglion cells synapse with the neurons of the lateral geniculate body. At this point, information from the retina is transferred from the optic tract to the optic radiation and hence to the visual cortex.

Lateral geniculate nucleus is one of the nucleus of the thalamus. Types of nucleus at the lateral geniculate nucleus are:

- 1) Dorsal nucleus.
- 2) Ventral nucleus

Dorsal Nucleus: Most of the nerve fibres terminate at the dorsal nucleus.

Ventral nucleus is rudimentary in human beings.

Blood Supply to Lateral Geniculate Nucleus

Posterior choroidal artery which is a branch of posterior cerebral artery.

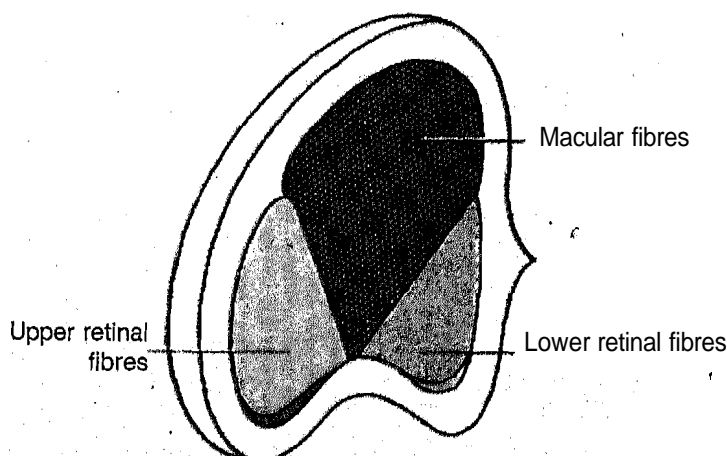


Fig. 6.6: Arrangement of fibres in the lateral geniculate body

Check Your Progress 2

- 1) Which retinal fibres cross to opposite side at optic chiasma?

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- 2) Which gland is situated below the optic chiasma?

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6.7 OPTIC RADIATION

Optic radiation or geniculocalcarine pathway arises from the lateral geniculate body and relay the fibres carrying visual impulses to the occipital lobe.

Course: Fibres from lateral geniculate nucleus ascend anterolaterally and initially the course is vertical but later becomes horizontal near the visual cortex. Bundles of optic radiations can be divided into:

- Dorsal bundle
- Lateral bundle
- Ventral bundle

Destination of Optic Radiation

Fibres within the optic radiation end in an extensive area of thin occipital cortex, known as striate cortex which is 1.4 mm in thickness.

Orientation of Nerve Fibres in the Optic Radiation

Dorsal Bundle: Representing superior retinal fibre arises from the medial aspect of the lateral geniculate body and passes to the dorsal lip of calcarine fissure.

Ventral Bundle: Representing inferior retinal fibres originates at the lateral aspect of the geniculate body and passes to the ventral lip of calcarine fissure.

Macular Fibres: Macular fibres represent a huge area within the optic radiation and end into the upper and lower lips of the calcarine fissure at the occipital lobe.

Blood Supply of the Optic Radiation

- 1) Anterior choroidal artery.
- 2) Deep optic branch of the middle cerebral artery.
- 3) Calcarine branch of the posterior cerebral artery.

6.8 VISUAL CORTEX

The visual cortex is situated on the medial aspects and at the posterior pole of the occipital lobe with slight extension to the lateral surface.

Shape: Elongated ovoid shaped.

Area: 3000 mm² in area.

The fibres of the optic radiation ends at the visual cortex which is also called area 17 of Brodman.

6.9 ARRANGEMENTS OF FIBRES IN THE VISUAL PATHWAY

First Order Neuron: When visual impulse falls on the retina, impulses originate at the photoreceptors, i.e., rods and cones. So the first order neuron is rods and cones of the retina.

Second Order Neuron: Impulse passes from the rods and cones to the bipolar cells which are the 2nd order neuron.

Third Order Neuron: Fibres pass from the bipolar cells to the ganglion cell, which is the third order neurons.

Fourth Order Neuron: The axons of the ganglion cells form the optic nerve. From the optic nerve, fibres pass into the optic chiasma. At the optic chiasma, the nasal fibres are crossed and pass to the opposite side. But the temporal fibres are uncrossed. These fibres ultimately end at the nucleus of the lateral geniculate body. This nucleus forms the fourth order neuron in the visual pathway. Fibres from the lateral geniculate body pass through the optic radiation and ends at the visual cortex, which is the ultimate destination of all visual fibres.

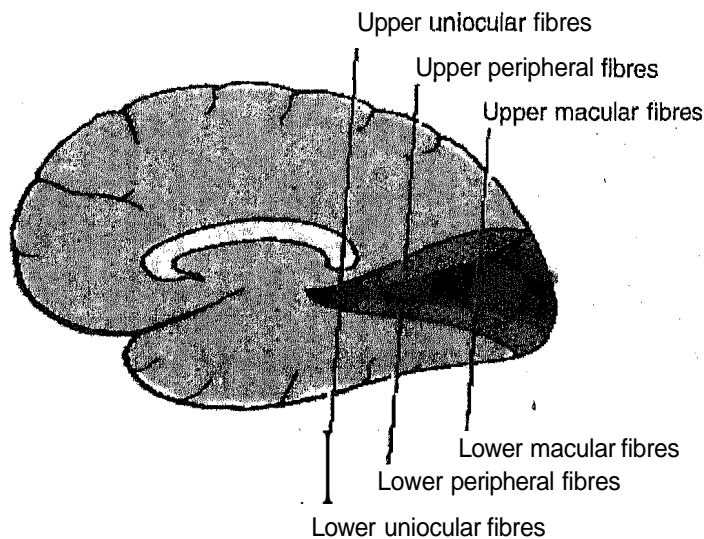


Fig. 6.7: Visual Cortex

Check Your Progress 3

1) What is striate cortex?

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2) Which is the first order neuron?

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6.10 LET US SUM UP

In this unit you have learnt that visual impulses pass from the eye to brain through optic nerve. Different parts of visual pathway include optic nerve, optic chiasma, optic tract, optic radiation. Visual fibres end at the occipital cortex. In the next unit you will learn about the anatomy of lids and lacrimal system.

6.11 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 1

- 1) Ganglion cells
- 2) Intra-ocular, intra-orbital, intra-canalicular, intra-cranial
- 3) Rods and cones
- 4) Occipital cortex

Check Your Progress 2

- 1) Nasal fibre
- 2) Pituitary gland.

Check Your Progress 3

- 1) Visual cortex
- 2) Rods and Cones