APPLIED ANATOMY OF OPTIC NERVE HEAD
(with relevance to Glaucoma)

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Embryology Of Optic Nerve:

Optic nerve develops from optic stalk, which connects optic nerve to forebrain. As stalk enlarges, it becomes thinner and its lumen is occupied by axons of ganglion cells. The optic nerve head is formed late in the embryonic period as the optic stalk encloses the hyaloid artery.
Myelinization of the optic nerve is produced by oligodendrocytes. It starts centrally, progresses centrifugally, and is complete approximately 1 year after birth.
Glial cells differentiate into astrocytes and oligodendrocytes. Astrocytes line the connective tissue septa and capillaries. Capillaries are derived from the pia mater that surrounds the proximal optic nerve. They get surrounded by connective tissue and are separated from the axons by a complete astrocyte sheet and a perivascular space. Vascularisation of optic nerve is complete by 18th week of gestation and an anterior anastomosis with circle of Zinn is established.

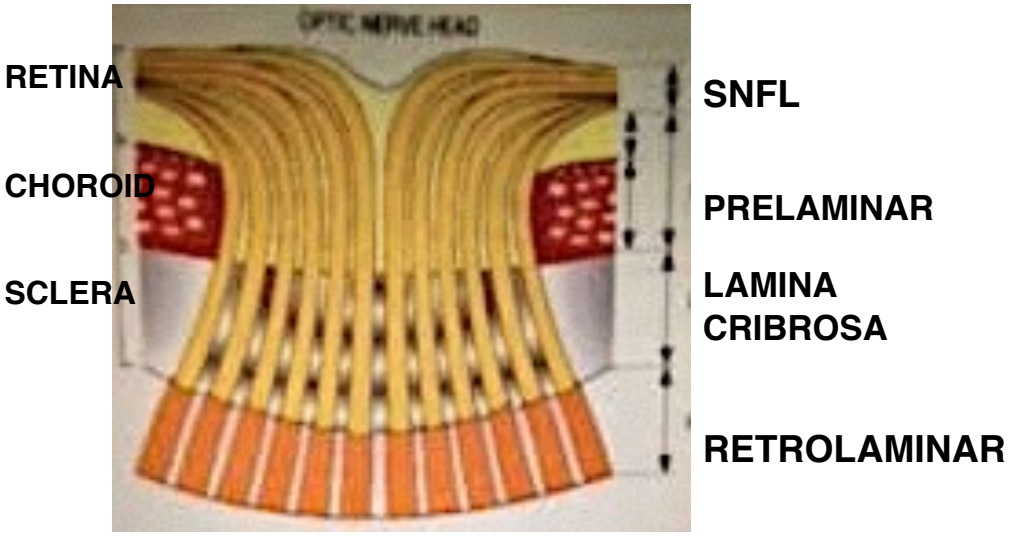
OPTIC NERVE:

It is a backward continuation of axons of the ganglion cells.
It contains sensory fibres from the retina, afferent fibres for light reflex and some centrifugal fibres, and is similar to other sensory tracts (white matter) of the brain because:
i: it is an outgrowth of brain
ii: It is not covered by neurilemma (so it cannot regenerate)
iii: It is surrounded by meninges.
iv: Fibres are 2-10 u in diameter as compared to 20 u in sensory nerves.
v: Both primary and sensory neurons are in retina
vi: It is 47-50 mm long and can be divided into 4 parts: Intraocular part= 1mm, Intraorbital part= 30mm, Itracanalicular= 6-9mm, Intracranial = 10mm

Intraocular part: Passes through sclera, choroid, and appears at the disc. It is 1.5 mm diameter. It expands by 3mm behind sclera due to the addition of myelin sheath

Divided into 4 portions:

1: <u>Superficial Nerve Fibre Layer (SNFL)</u>: has axon bundles (94% nerve fibres and 5% astrocytes). Optic disc is covered by ILM which is a thin layer



of astrocytes. It separates it from the vitreous, and continues with the ILM of retina. When central portion of this membrane gets thickened, it is called the CENTRAL MENISCUS OF KUHNT.

2: **<u>PRELAMINAR REGION:</u>** Predominantly made up of neurons and astroglial tissue. Border tissue of JCOBY (a cuff of astrocytes) separates the nerve from choroid.

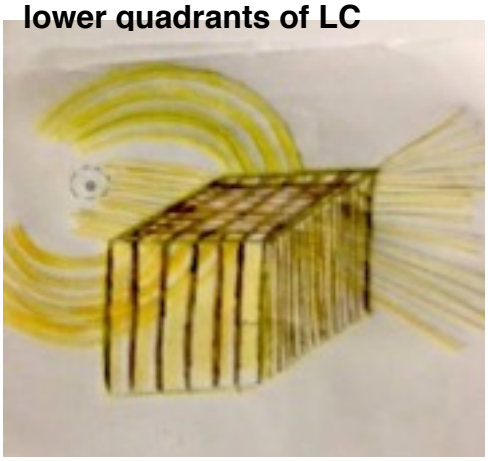
3: **<u>Lamina cribrosa (LC):</u>** Bundles of nerve fibres leave the eye through LC which is a fibrillar sieve composed of fenestrated sheets of scleral connective tissue lined by glial tissue. The fibrous trabeculae are formed from interweaving skeins of collagen fibres many of which are arranged tangentially to the canals in the lamina. The trabeculae contain collagen type III (supporting tissue collagen) and relatively little collagen type I (hard collagen that forms bony tissue).
The canals are larger in the superior and inferior quadrants of the lamina cribrosa (that supports fibres from the upper and lower temporal quadrants of

retina) than in the nasal and temporal quadrant that supports the papillomacular bundle.

Applied:

1:This lack of support from the collagenous trabeculae at the upper and lower poles of the nerve head makes the axons from these quadrants more vulnerable to mechanical damage in nasal and temporal quadrants. This can be compared to the foundation of a building. The Iron Grid Structure that supports the building is weaker as supporting beams are widely placed in upper and lower halves, therefore the structure gives way in these regions as pressure rises.

Large canals in upper & lower quadrants of LC



2: Moreover, the fibres from upper & lower temporal quadrants arch around the macula, taking a long, curved course to reach the nerve head.
This long course, as well as lack of support bot play an additive role to cause damage to these fibres primarily in early glaucoma.

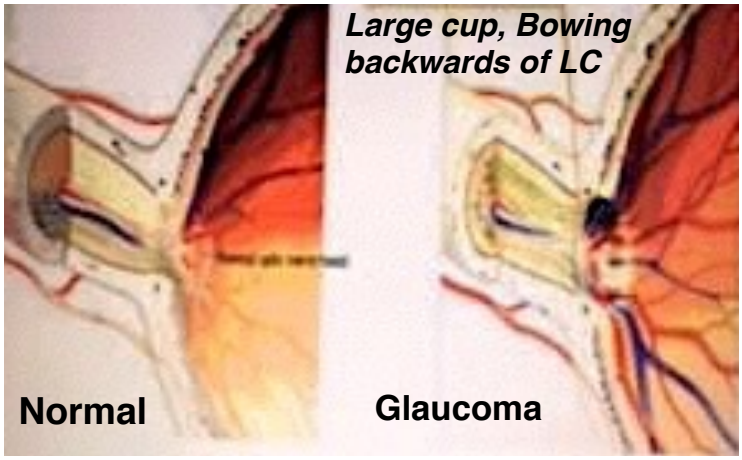
3:The astrocyte web in the lamina cribrosa plays an important role in the mechanical and metabolic support of optic nerve axons. The rim of collagenous connective tissue with some mixture of glial cells which intervenes between choroid , sclera, & optic nerve and is known as BORDER OF ELSCHING. *It has been found on dissection that the optic nerve and lamina can be easily separated from the sclera and dural sheath suggesting that the connective tissue links between the lamina and the sclera are far from substantial. Therefore as IOP rises, the LC separates from sclera and bends backwards.*

4: Optic nerve increases in diameter by some 40% as it leaves the lamina cribrosa. This increase in bulk occurs as the non-myelinated axons in the lamina cribrosa become myelinated in the optic nerve. Myelin is like a fatty cushion that supports the axons from mechanical damage. *Lack of Myelin in*

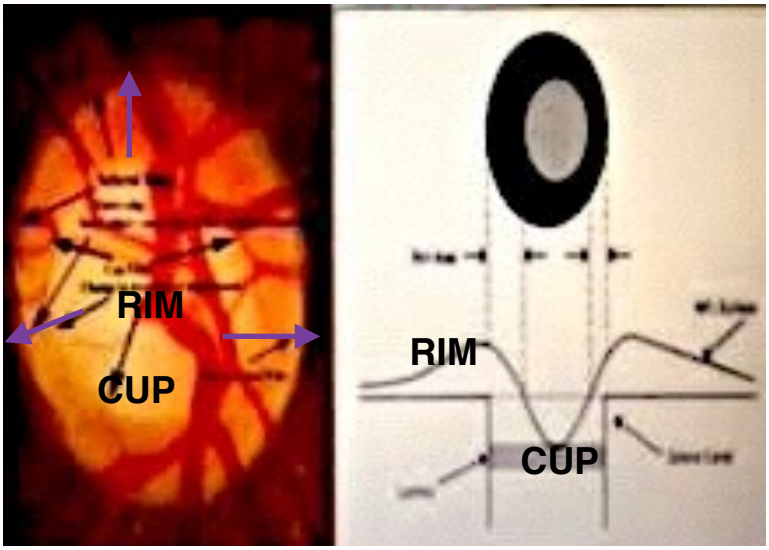
SNFL, Prelaminar and Laminar regions of the optic nerve, makes axons particularly vulnerable to mechanical, chemical and ischemic injury.
The subarachnoid space surrounding the optic nerve is seen to extend up to the sclera and the arachnoid trabeculae cross the subarachnoid space to join the pial coating of the optic nerve.

4: RETROLAMINAR REGION: This area is characterised by a decrease in astrocytes and acquisition of myelin sheath supplied by oligodendroglia. Myelin sheath doubles the diameter of optic nerve from 1.5 at the LC to 3 mm as it passes through the sclera.

OPTIC DISC APPEARANCE ON FUNDOSCOPY:



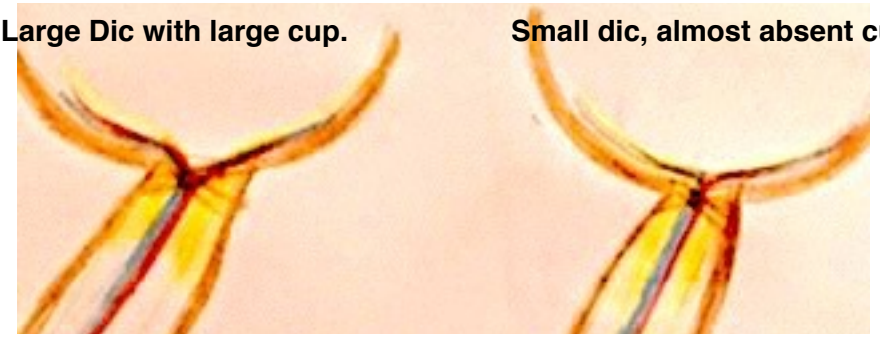
THE part of optic nerve head visible iOPHTHALMOSCOPICALLY is termed the disc. Its parts are the cup & neuroretinal rim separated by scleral ring of Elsching from a zone of PPA present on temporal side. The neuroretinal rim appears pink due to a rich capillary supply.



This small zone of PPA is due to an oblique entry of optic nerve into the eyeball, because of which, the

vessels of annulus of Zinn reach the nasal end of the cup and keep it Pink , while they fall short on the temporal side, causing a pale temporal crescent.

Disc Size: vertically oval 9% longer than horizontal dimension.
ranges from 0.86 - 5.54 mm sq.



Macrodisc: > than 4sq mm, may be normal or be associated with a pit, morning glory syndrome. high myopia, buphthalmos.
Larger discs have larger cups as Central retinal vessels divide into the temporal & nasal branches while they are inside the LC . The rim has the same number of axons in small or a large disc. So axons have more space to occupy in a large disc and occupy its periphery (along with a rich supply of capillaries), so the central cup appears larger.

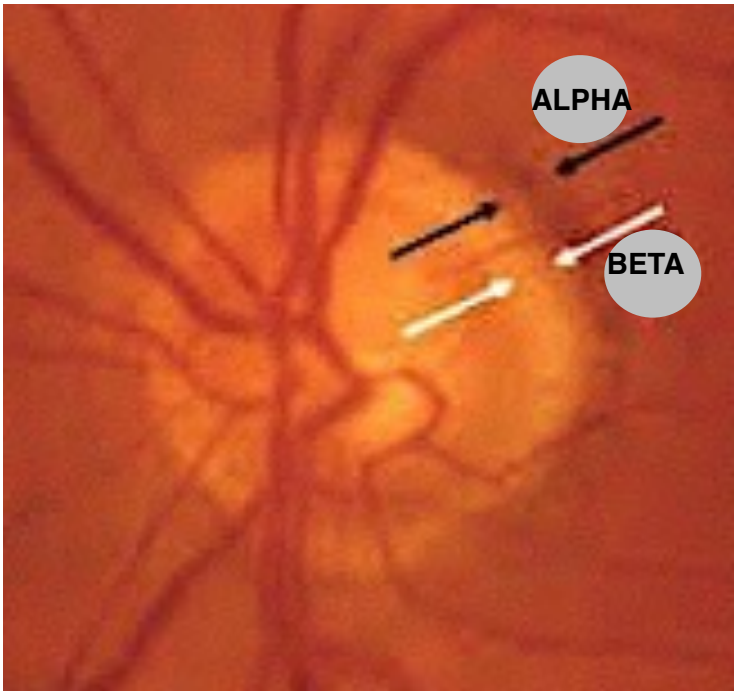
Micro disc < 1.29 sq mm . The same number of axons are crowded in a small area. The central retinal vessels are pushed into the centre of the optic nerve and the disc, so there is hardly any cup visible, as shown in the above diagram. This is seen in high hypermetropes.

NAION (commoner is smaller discs), due to reduced perfusion and of limited space, also in raised IOP at the optic nerve head, the orthograde axoplasmic flow is blocked.

RIM: contains axons as they enter the disc. It is broadest inferiorly, then superior, nasal , temporal.
There is more axonal mass and vascularity in inferotemporal region . Thats why flame shaped hges at 11 and 6 ‘o clock are an early sign of glaucoma.

Larger pore size in superior and inferior regions causes a vertical enlargement of the cup.

PPA: PERIPAPILLARY ATROPHY:



Divided into two zones:

Zone alpha: (choroidal crescent) a more peripheral zone: a hypo / hyperpigmented area next to retina where RPE failed to extend to the disc margin.

Zone beta: is central to zone alpha and consists of an area with atrophy of RPE and choriocapillaris, with larger choroidal vessels showing through.

Both these zones enlarge in chronic glaucoma.

RETINAL VESSELS: THE COURSE OF ARTERIES AND VEINS IS SIMILAR TO AVOID EXCESSIVE SHADOWING OF PHOTORECEPTORS.

VENOUS PULSATIONS SEEN AT THE DISC IN 15-90% NORMALLY, DUE TO COLLAPSE OF VEINS AS OCULAR PRESSURE RISES WITH ARTERIAL INFLOW INTO UVEAL VESSELS.

Visible arterial pulsations are pathological : seen in High IOP and aortic incompetence.