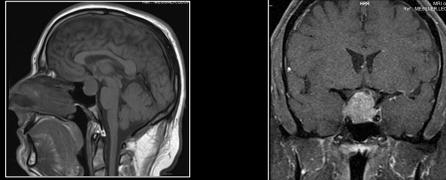


# “Mind-Bending” Neuro-Oph Grand Rounds: “From the Chiasm & Beyond”



Leonard V. Messner, OD, FAAO  
Professor of Optometry  
Vice President for Strategy & Institutional Advancement  
Illinois College of Optometry



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## Disclosure Statement

- King Devick Technologies (scientific advisory board)
- Heidelberg Engineering (professional advisory board)
- Horizon Therapeutics (professional advisory board)

All relevant relationships have been mitigated

2

Anatomy slides courtesy of Lorraine Lombardi, PhD



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## Key Points

- Neuroanatomical planes of the body
- Imaging techniques and scan selection
- Correlative neuro-anatomy and neuroradiology for visual pathway lesions
  - Chiasm
  - Retro-chiasm

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## Planes of the Body

- Axial
- Sagittal
- Coronal

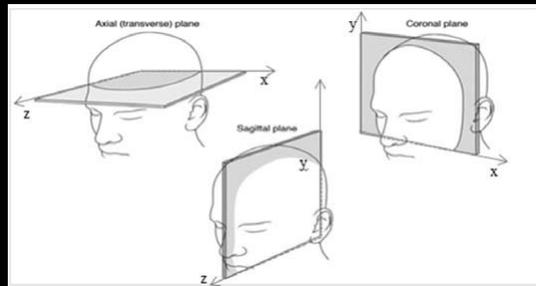
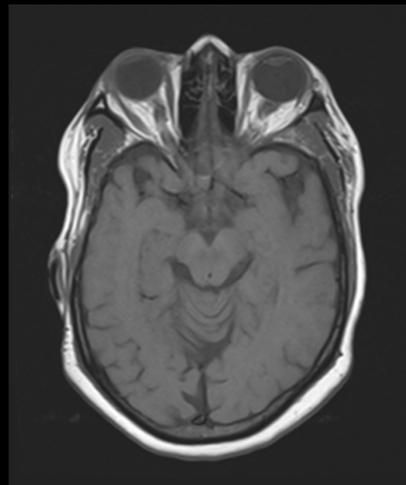


Image reference: [https://www.researchgate.net/publication/280608869\\_Brain\\_MRI\\_literature\\_review\\_for\\_interdisciplinary\\_studies/figures?to=1](https://www.researchgate.net/publication/280608869_Brain_MRI_literature_review_for_interdisciplinary_studies/figures?to=1)

5

## Axial

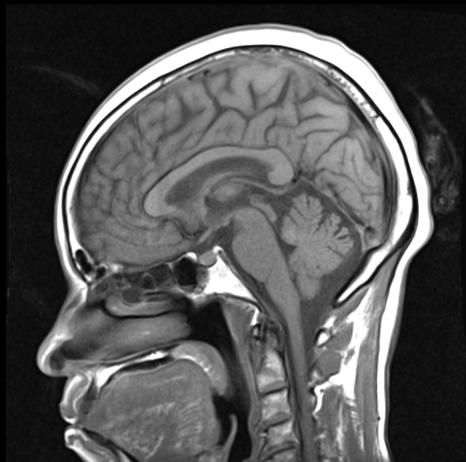
right



left

6

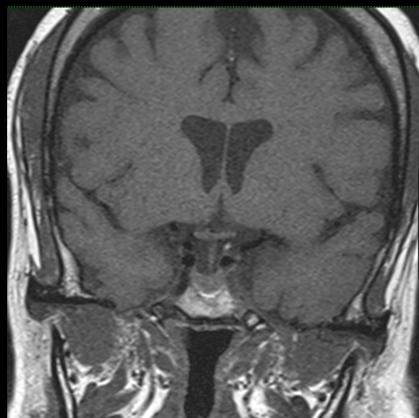
# Sagittal



7

# Coronal

right



left

8

## Neuroimaging Studies

- Computed tomography (CT)
- Magnetic resonance imaging (MRI)

9

## Ordering a Scan

- Scan selection (e.g. MRI, CT) and testing protocol:
  - Brain
  - Orbits
  - Pituitary/chiasm
- With / without contrast
- Clinical impression/question to be answered
- Medical history

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# COMPUTED TOMOGRAPHIC (CT) SCANNING

11

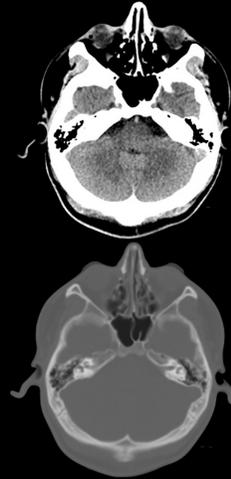
## Background

- Increased absorption of x-rays by atoms of higher atomic # (Ca, I, Fe)
- Axial & coronal image planes
- Iodinated IV contrast
  - contraindicated for px's with hx of allergic rxn to previous contrast studies or shellfish, pregnancy or renal disease

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## CT “Windows”

- Brain / Soft Tissue
  - 50-350 HU (narrow window)
- Bone
  - 400-2000 HU (wide window)

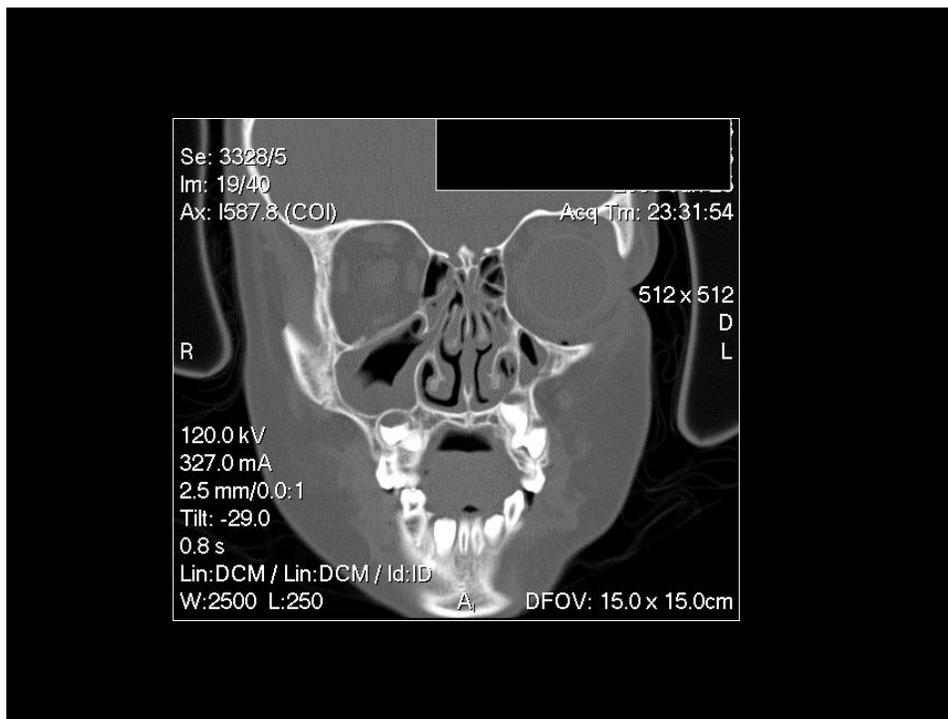


13

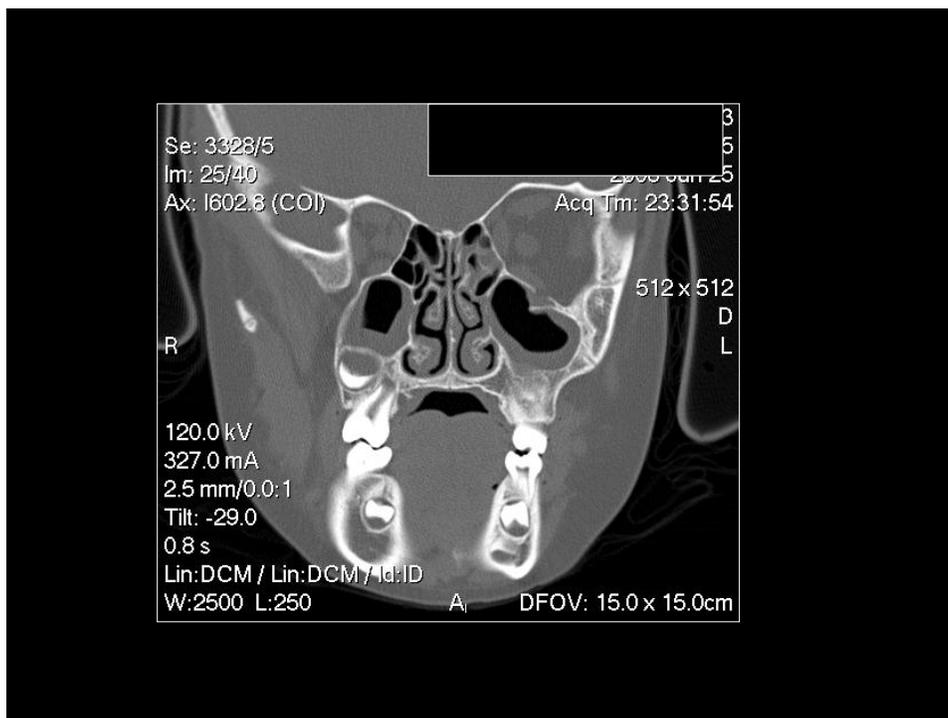
## 7 y/o White Male

- Hit in left eye with baseball bat
- + ecchymosis & sub conj hem
- No subjective diplopia or motility restriction
- Exoph = 17mm OU

14



15



16

## 27 y/o Arabic Male

- c/o vertical diplopia following blunt trauma
- Diplopia:
  - Near > Dist.
  - Alleviated on left head tilt

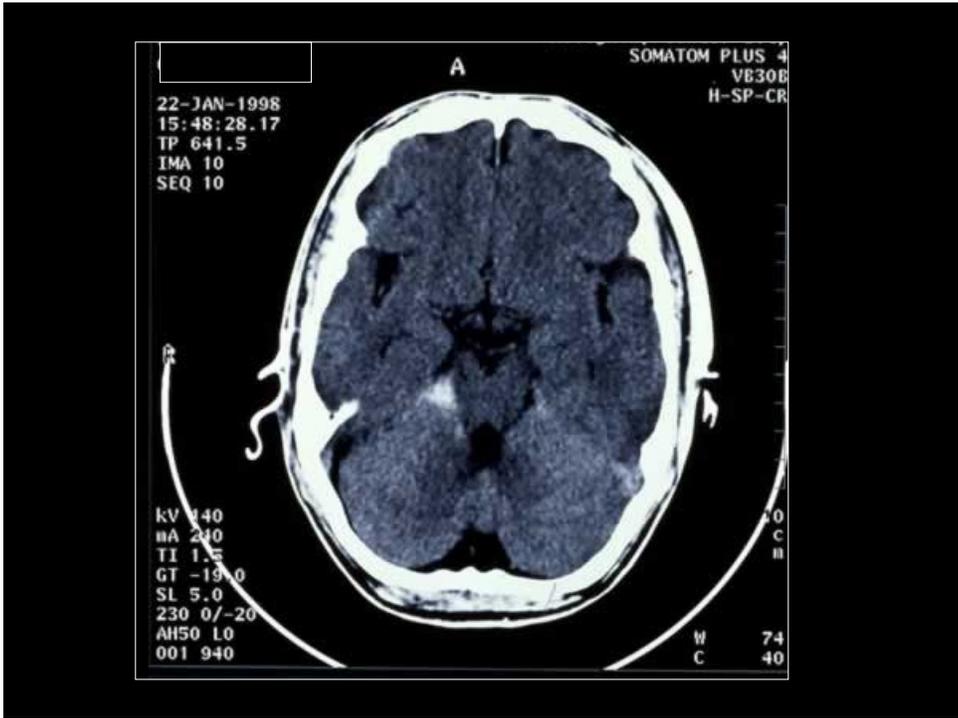
17



18



19



20

## PROS & CONS OF CT

- CHEAP
- QUICK
- ADAPTABLE FOR ANGIOGRAPHY (CTA)
- ACUTE BLOOD
- BONE DETAIL & ORBITS
- SOFT TISSUE DIFFERENTIATION
- "BEAM-HARDENING" ARTIFACTS
- RESTRICTED IMAGING PLANES (AXIAL & CORONAL)
- IONIZING RADIATION



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## MAGNETIC RESONANCE IMAGING (MRI)

22

## Background

- Px in strong magnetic field
- Alignment vector for hydrogen atoms (protons)
- Radiofrequency (RF) pulse
- Energy absorbed / released
- Released signal (“echo”) analyzed by receiver coils
- Computed image construction

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## MRI Sequencing

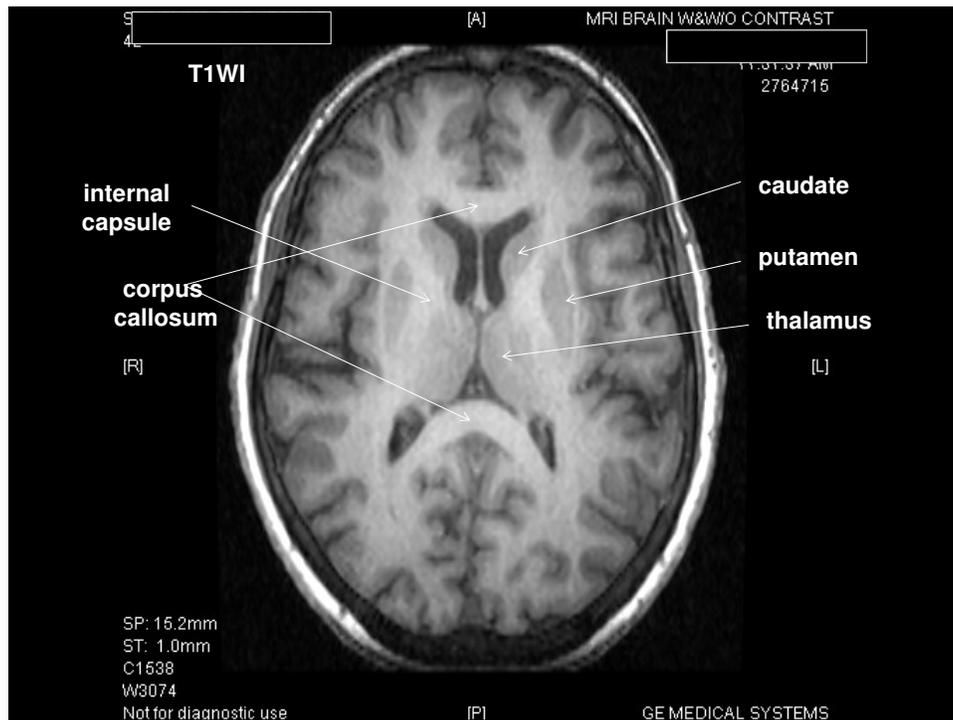
- T1-weighted
- T2-weighted
- Fluid attenuated inversion recovery (FLAIR)
- Fat suppression
- Diffusion-weighted imaging (DWI)

24

## T1-Weighted Imaging

- Short TR ( $\leq 600$  ms)
- Short TE ( $\leq 30$  ms)
- Good resolution of anatomical detail
- Adaptable with contrast infusion

25



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## T2-Weighted Imaging

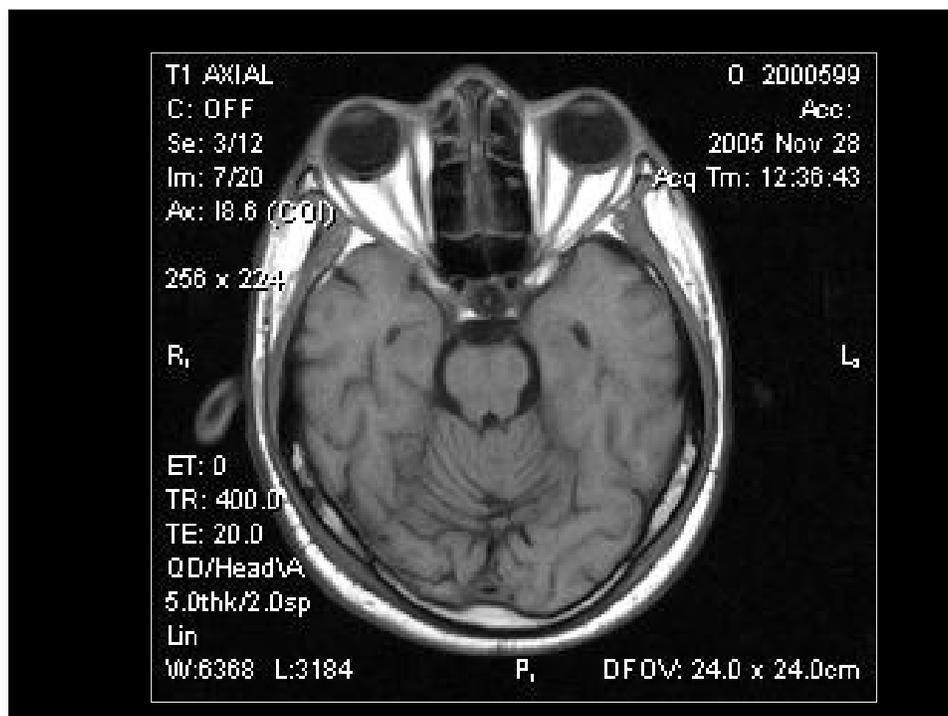
- Long TR ( $\geq 2000$  ms)
- Long TE ( $\geq 80$  ms)
- Good identification of pathology (fluid)
  - Edema
  - Demyelination
  - Infarction

27

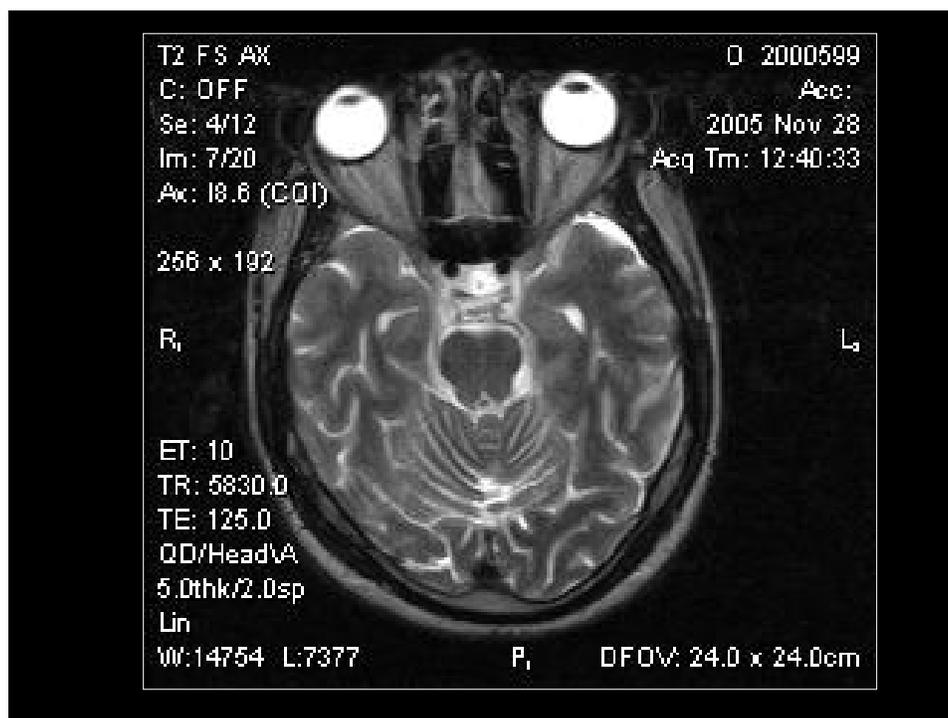
### Signal Intensity (T-1 vs. T-2) Normal Brain

Structure	T-1 weighted	T-2 weighted
Brain (white/gray)	bright/darker	dark/brighter
CSF/H <sub>2</sub> O	dark	bright
Vitreous/aqueous	dark	bright
Fat	very bright	less bright
Rapid blood flow	black	black
Bone / air	black	black

28



29



30

## 56 y/o AA Male

- Clinical concern for right Horner syndrome
- Right-side facial anhidrosis & decreased tearing
- BVA:
  - 20/20 OD
  - 20/20 OS

31



32



33

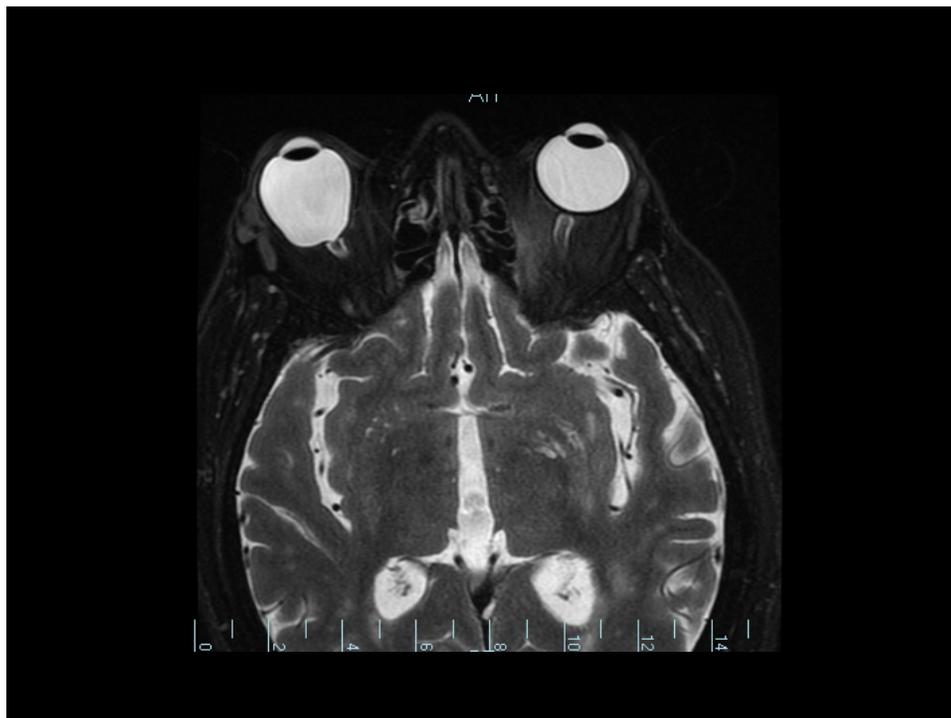
T-2  
Likes  
H<sub>2</sub>O

34

## 66 y/o AA Male

- Long standing history of proptosis OD
- BVA:
  - LP OD (band keratopathy)
  - 20/20 OS

35



36

## Signal Intensity (T-1 vs. T-2) Abnormal Tissue

Lesion	T-1 weighted	T-2 weighted
Infarct	Dark	Bright
Blood	Bright (early & late subacute)/ Dark (hyperacute & chronic)	Bright (hyperacute & late subacute) Dark (acute / early subacute & chronic)
Demyelinating plaques	Normal (acute) Dark (chronic "black hole")	Bright
Protein	Dark (low-very high%) Bright (mod.-high%)	Bright (low%) Dark (mod.-very high%)

37

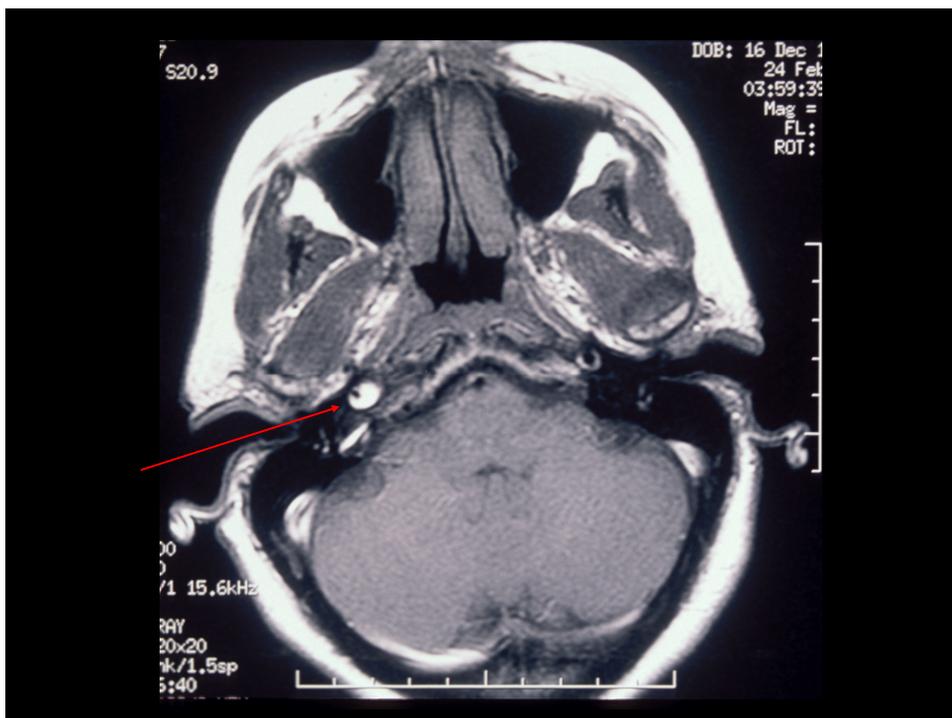
### 37 y/o AA Male

- Hx of recent auto accident with whiplash injury
- Transient monocular blindness, OD
- Right side neck pain with intracranial noise

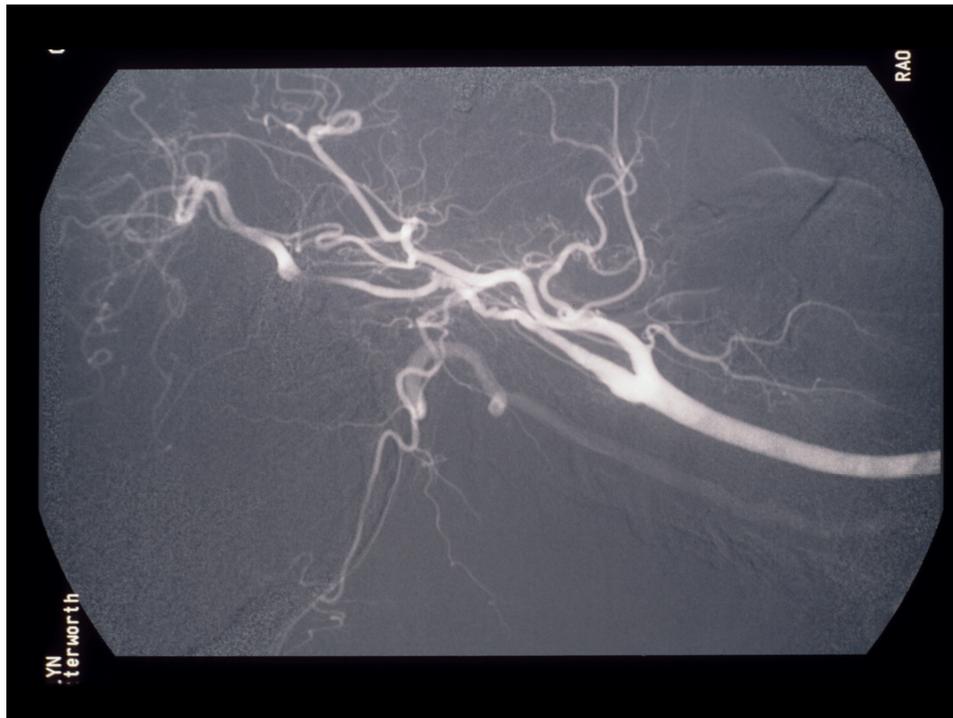
38



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## Fluid Attenuated Inversion Recovery (FLAIR)

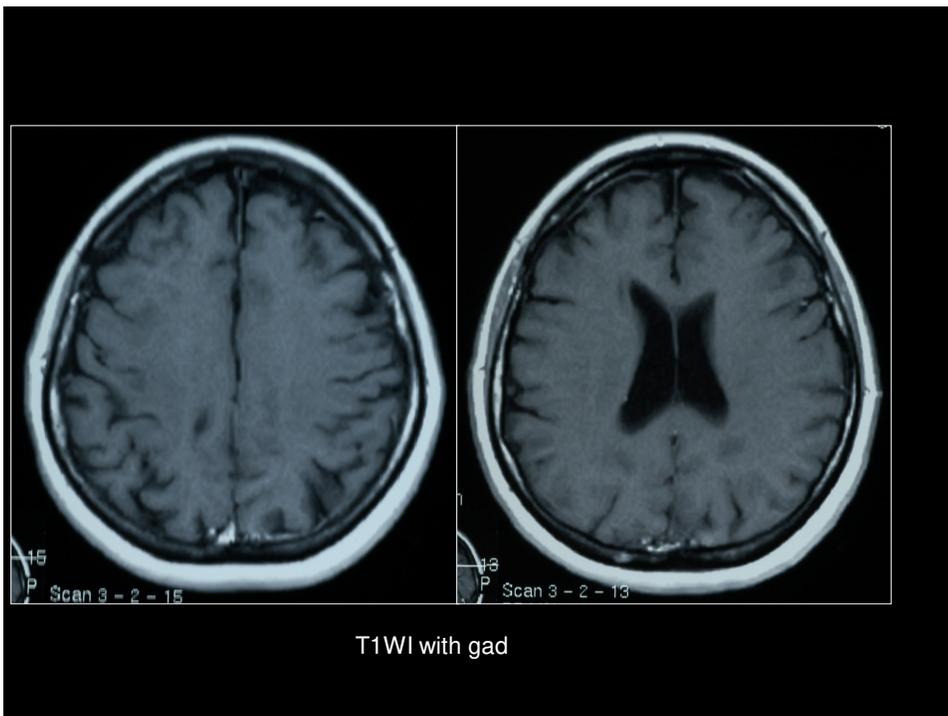
- T2WI with suppression of CSF signal
- Increased sensitivity for paraventricular lesions:
  - *Ischemic foci*
  - *Demyelinating plaques*

42

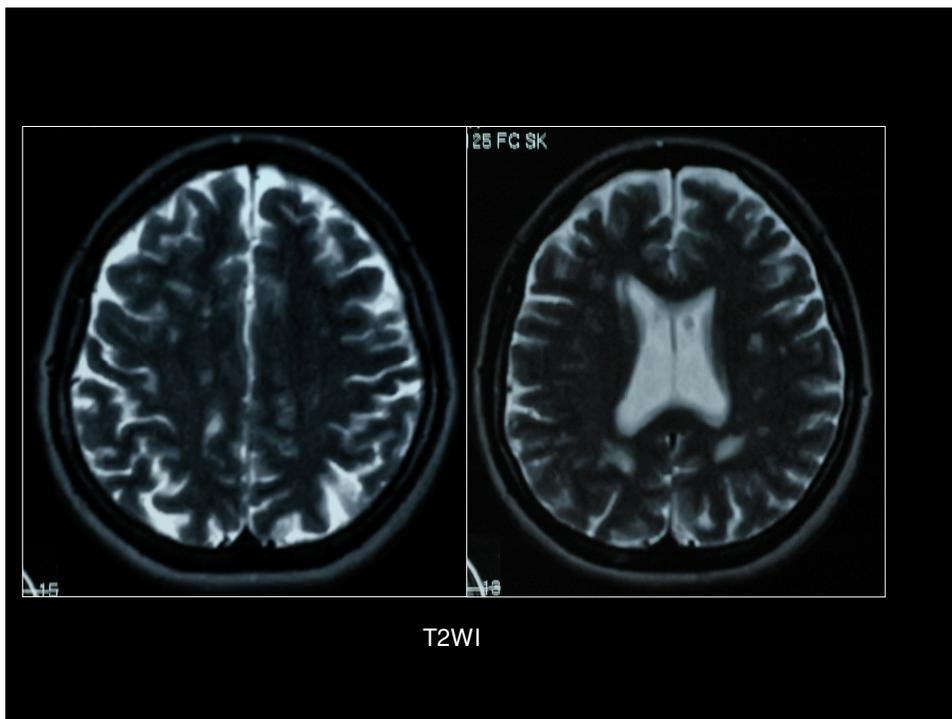
## 42 y/o Hispanic Female

- Previous bout of optic neuritis, OS
- H/o RR-MS

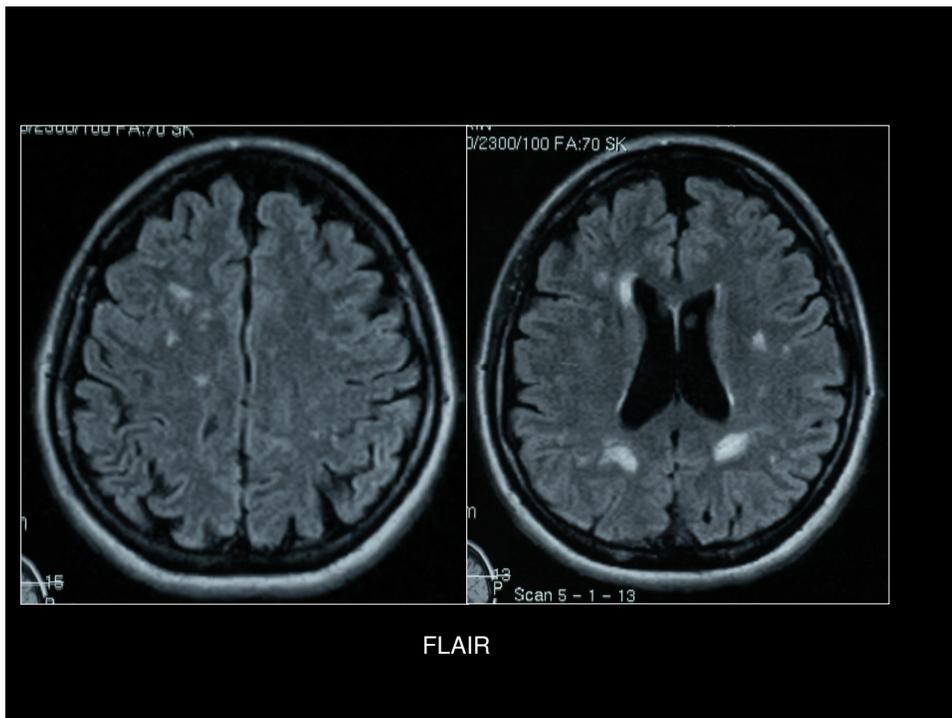
43



44



45



46

## Fat Suppression

- Short tau inversion recovery (STIR)
- Fat saturation (FS)
  - **Orbits**
  - Neck
  - Bone marrow



56



T1 Axial

T1 Axial  
FS post infusion

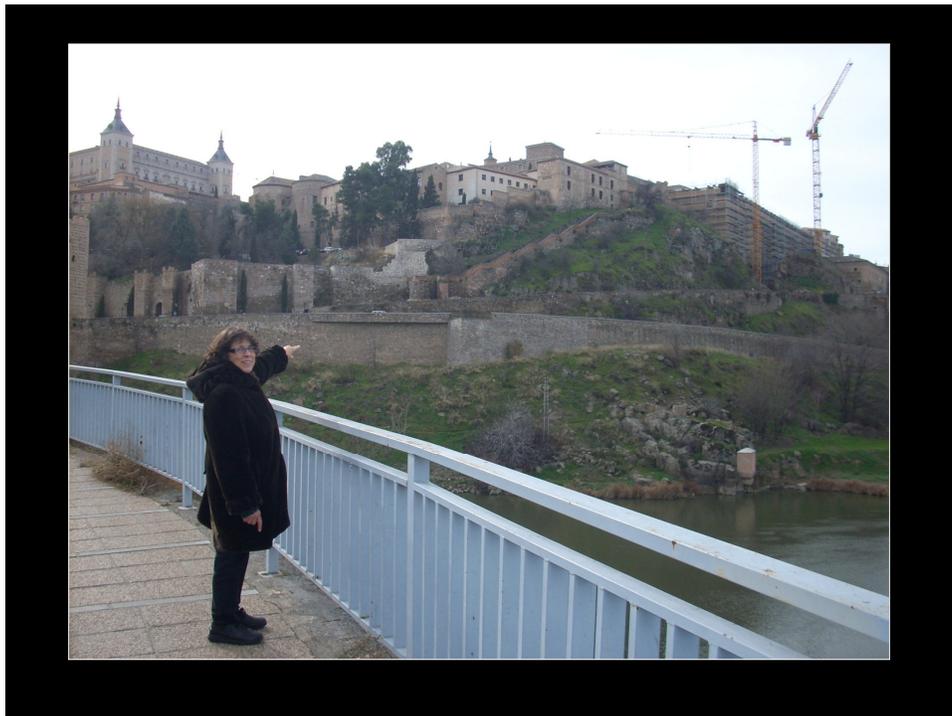
57

## Paramagnetic Contrast Enhancement



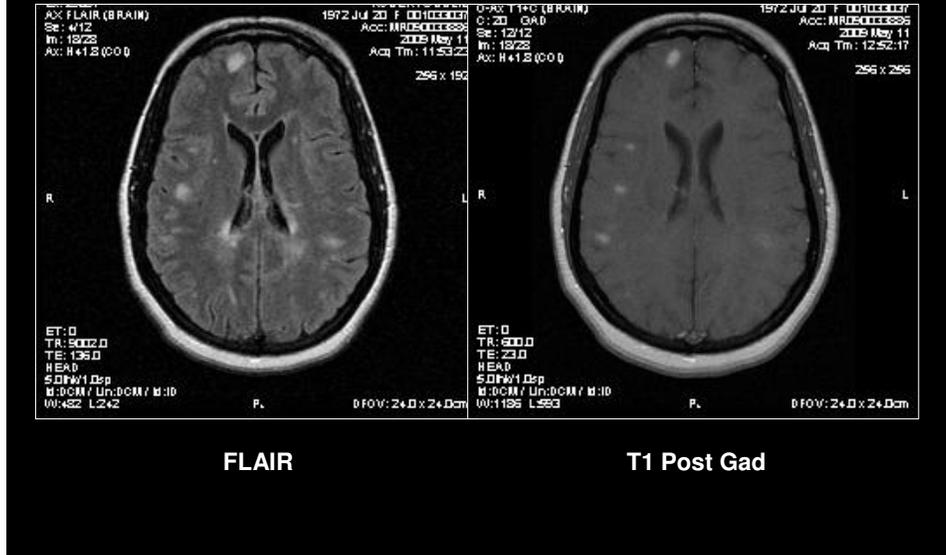
- Gadolinium (Gd-DTPA)
- Breakdown of blood-brain barrier
  - Edema
  - Vascularization
- Hyperintensity on T1 (shortens T1 signal)

58



59

42 y/o Female with optic neuritis

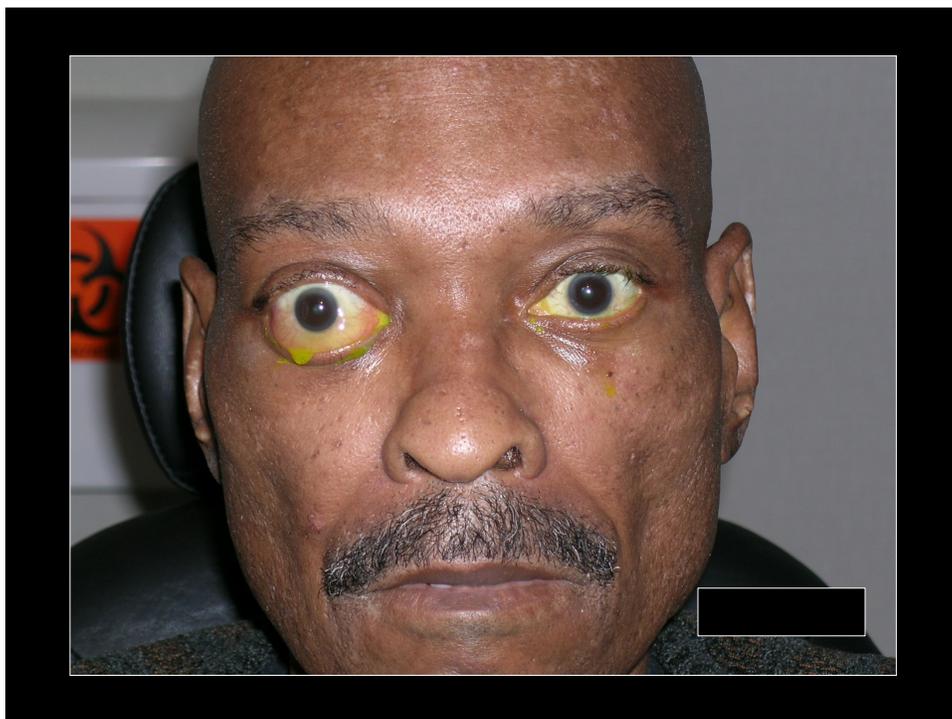


60

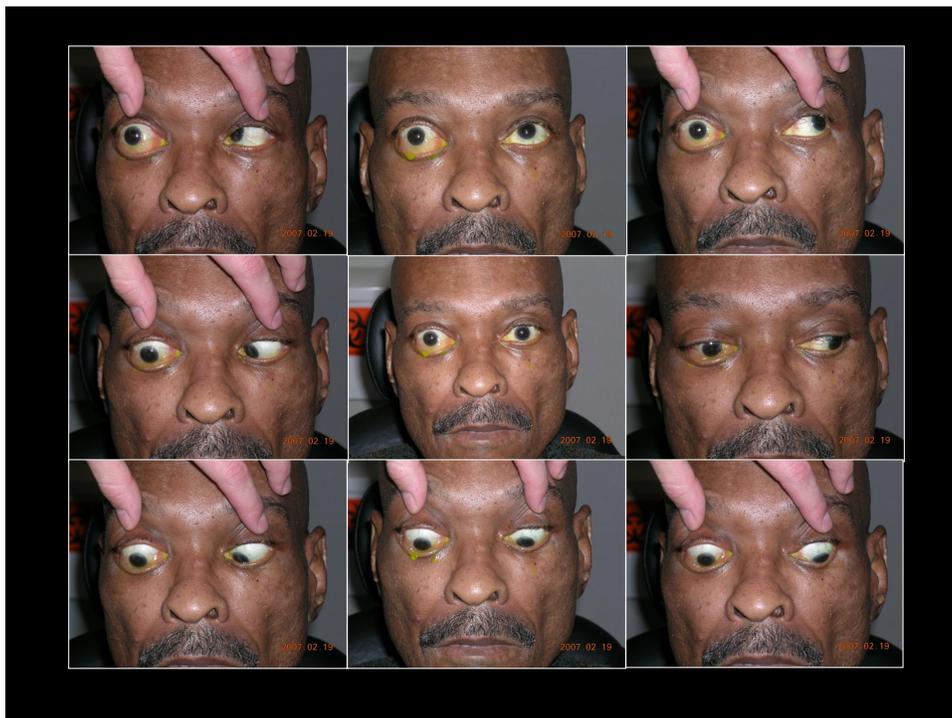
## 58 y/o AA Male

- Progressive vision loss and proptosis, OD
- 6-month history of progressive pulmonary dysfunction
- BVA:
  - 20/80 OD (+ RAPD)
  - 20/20 OS

61



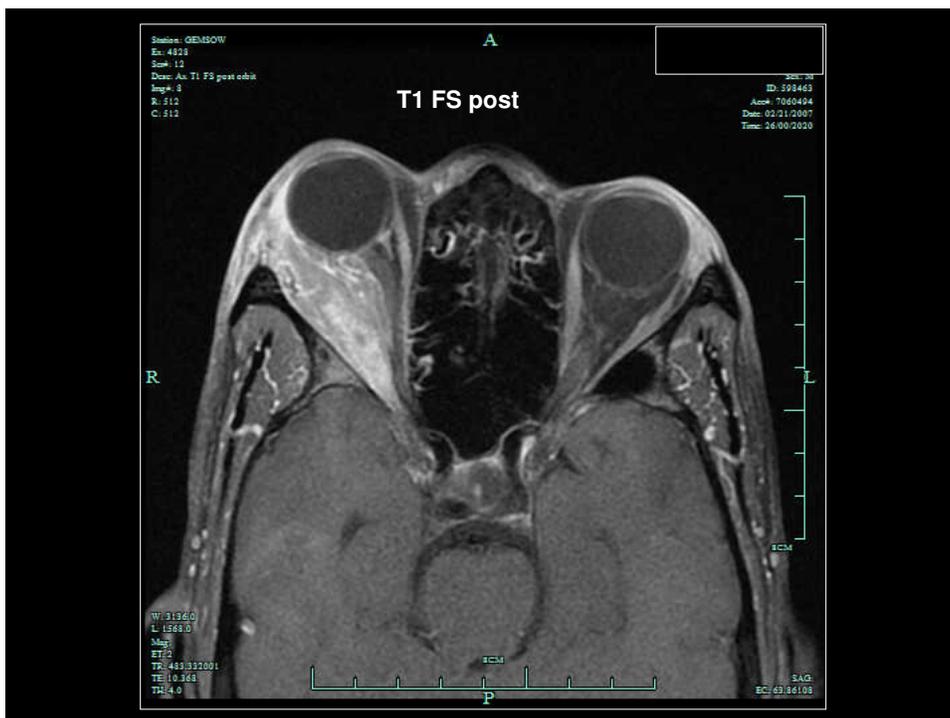
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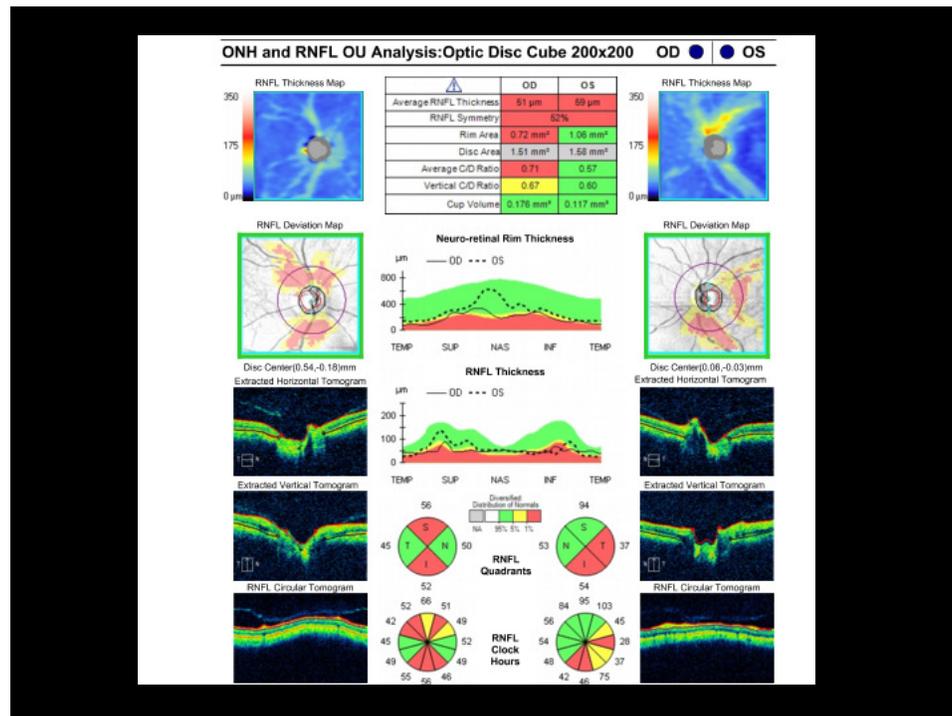


65

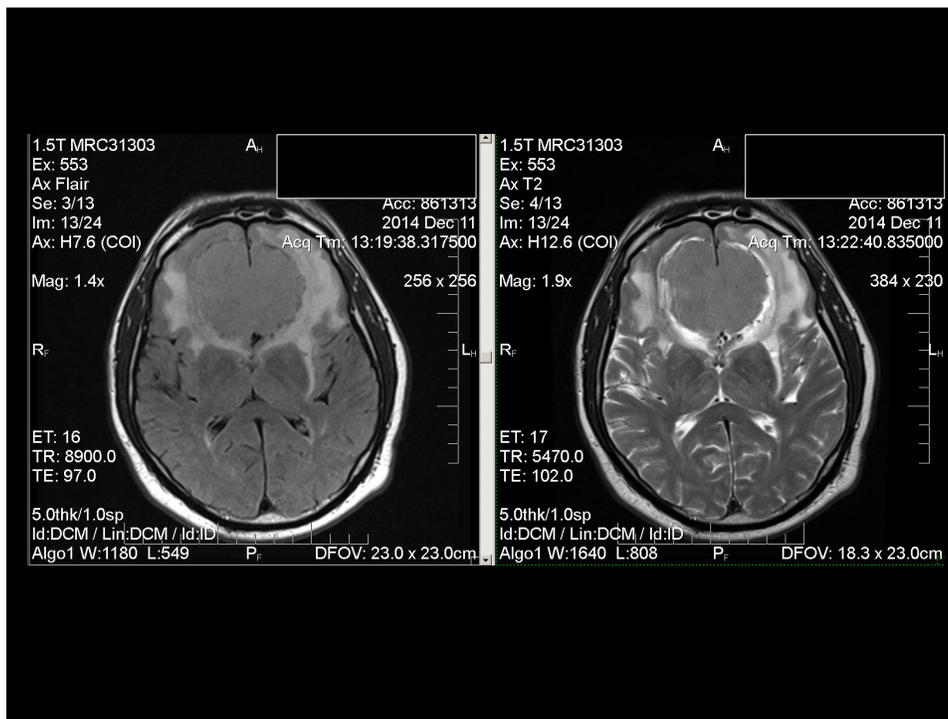
# 71 y/o AA Male

- Progressive vision loss OD > OS (months to years?)
- BVA:
  - LP OD
  - 20/60 OS

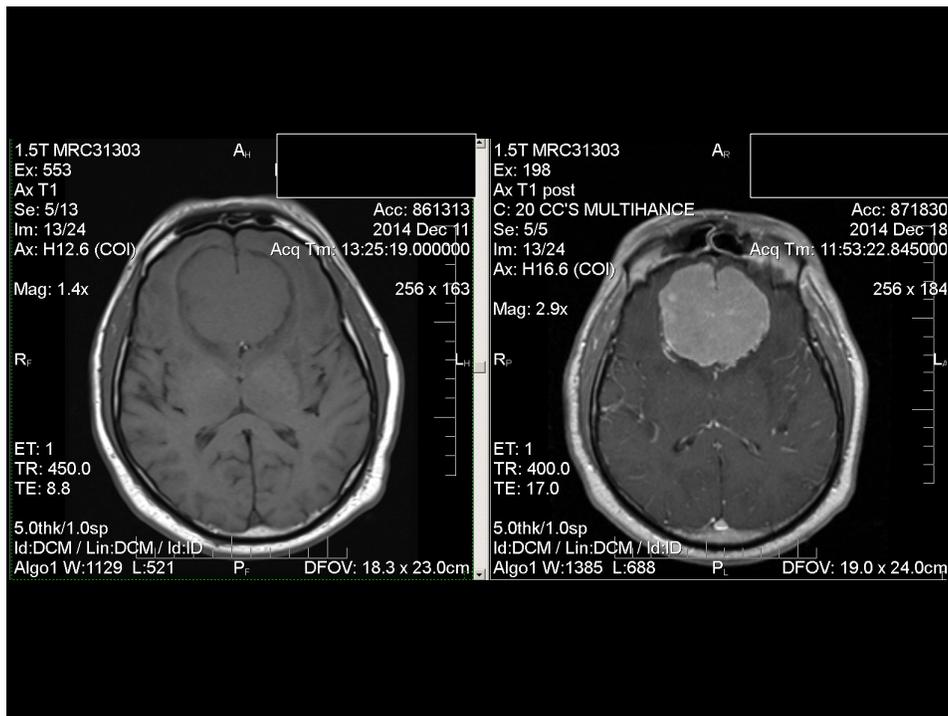
66



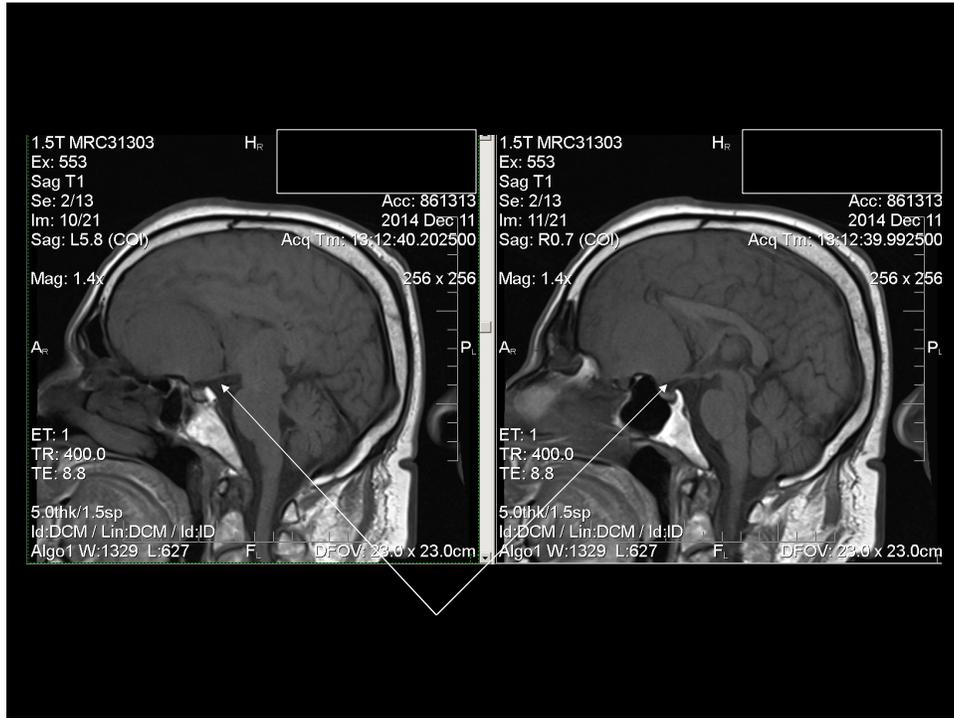
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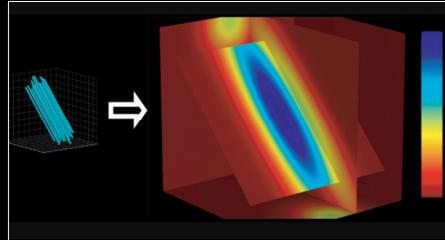
*One thing you should never do is drink a few glasses of Ciroc vodka at an open bar event and then have a glass of straight Hennessy afterwards on a school night.*

Mondayramble.com

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## Diffusion-Weighted Imaging

- Variant of T2WI
- Assessment of the ability of water molecules to freely move (diffuse) within biological tissue (“Brownian motion”)
- Within white matter, water molecules show a linear diffusion parallel to axonal fibers



Hagman P, et al. *RSNA* 2006

77

## DWI (cont.)

- Acute stroke → translocation of water from the extracellular to the intracellular compartment, where water mobility is relatively **more restricted** (cytotoxic edema)
- Restricted diffusion = hyperintensity on DWI

78

## DWI (cont.)

- Immediate detection of cerebral ischemia
  - Increased signal intensity within minutes
  - maximal signal intensity within 2-4 days
  - Slow return to baseline

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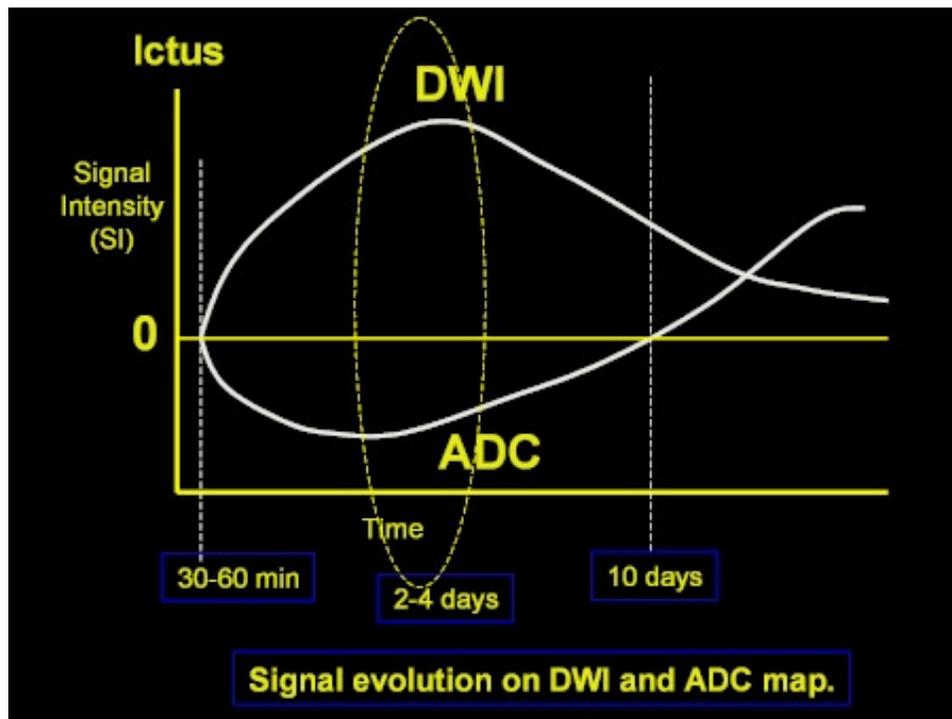
## Apparent Diffusion Coefficient “ADC Map”

- Chronicity of stroke:
  - Acute infarct (cytotoxic edema) = low ADC
  - Subacute/chronic infarct (vasogenic edema) = high ADC



“T2 Shine Through”

80

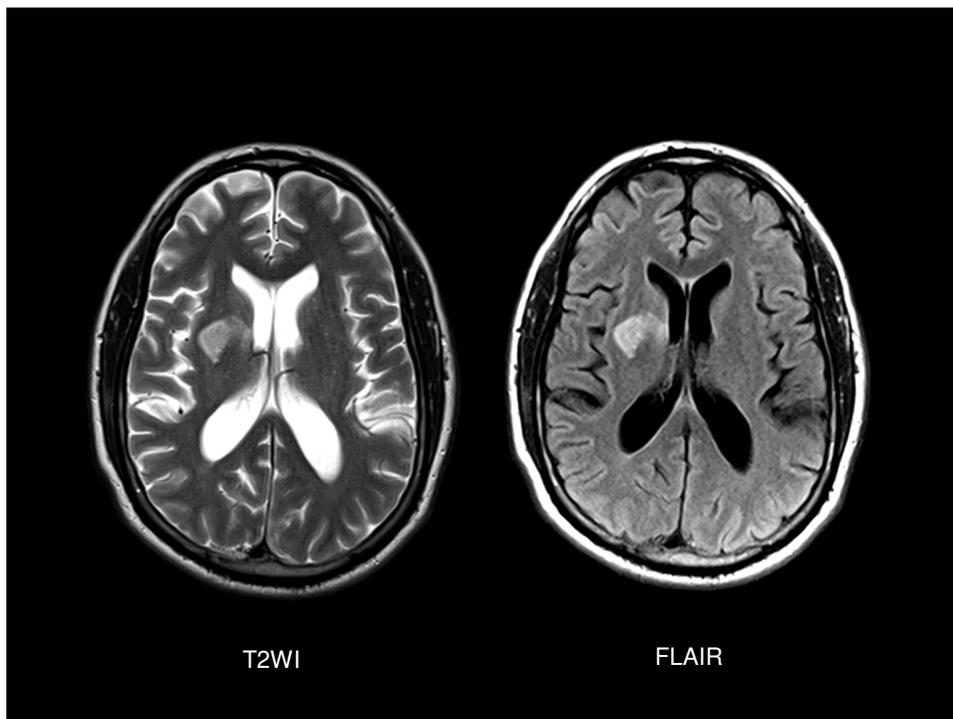


81

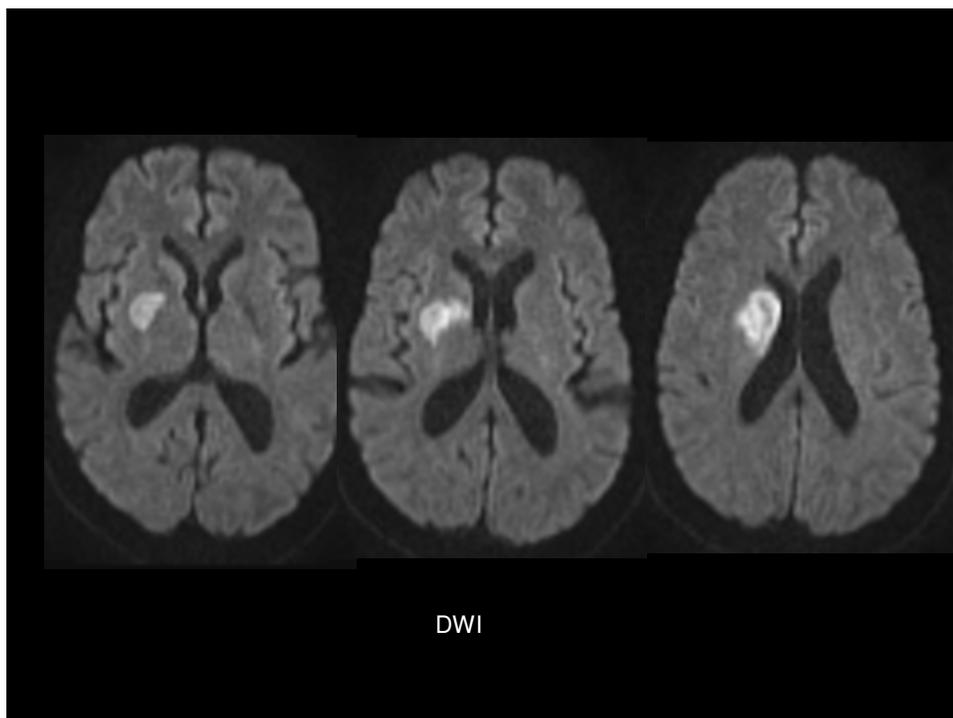
## 46 y/o Hispanic Male

- Evaluation of optic atrophy OU
- H/o diabetes and hypertension
- BVO:
  - 20/20 OD
  - 20/20 OS
- Recent-onset tremor, confusion, depression, lower left facial weakness and eye tracking problems (**impaired saccades greater looking to left**)

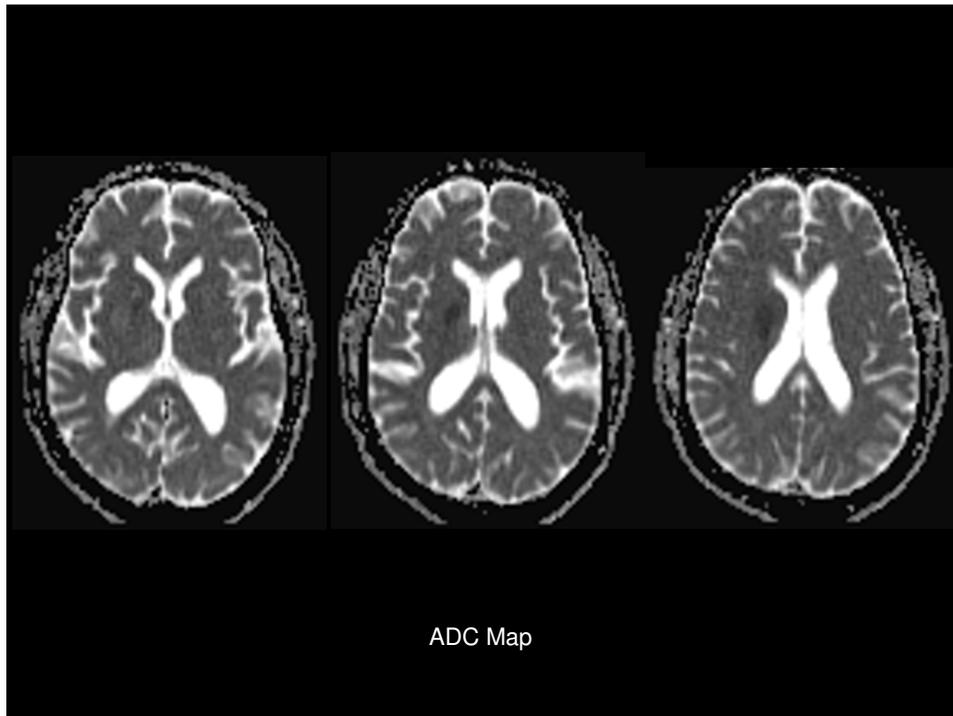
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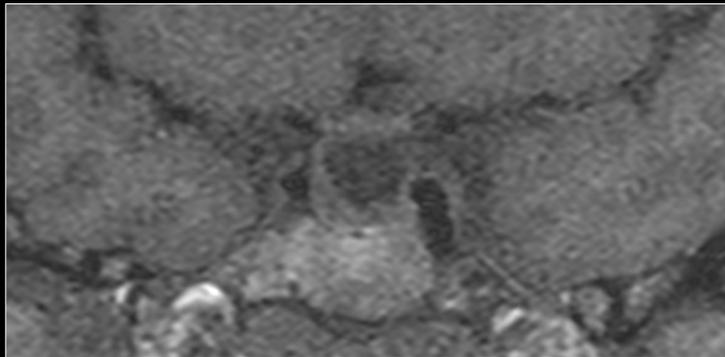
## PROS & CONS OF MRI

- **SOFT TISSUE**
- **POSTERIOR FOSSA**
- **SAGITAL PLANE**
- **DEMYELINATION / MS**
- **CHRONICITY OF STROKE**
- **\$\$\$**
- **LONGER TIME**
- **CONTRAINDICATED WITH METAL, PREGNANCY & OBESITY**



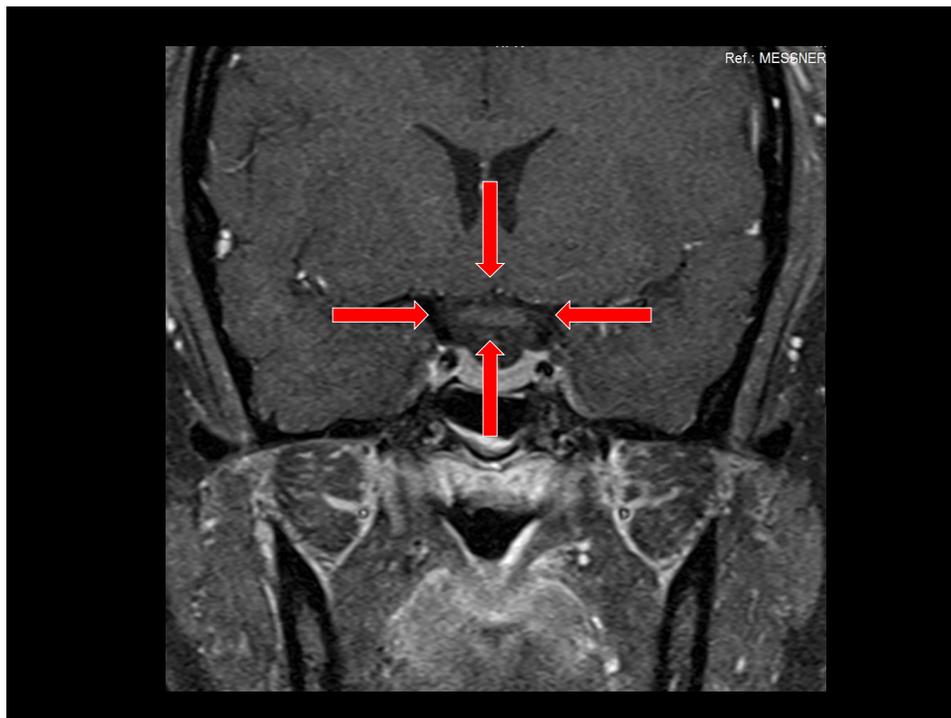
90

***“The chiasm lives in a rough neighborhood.”***

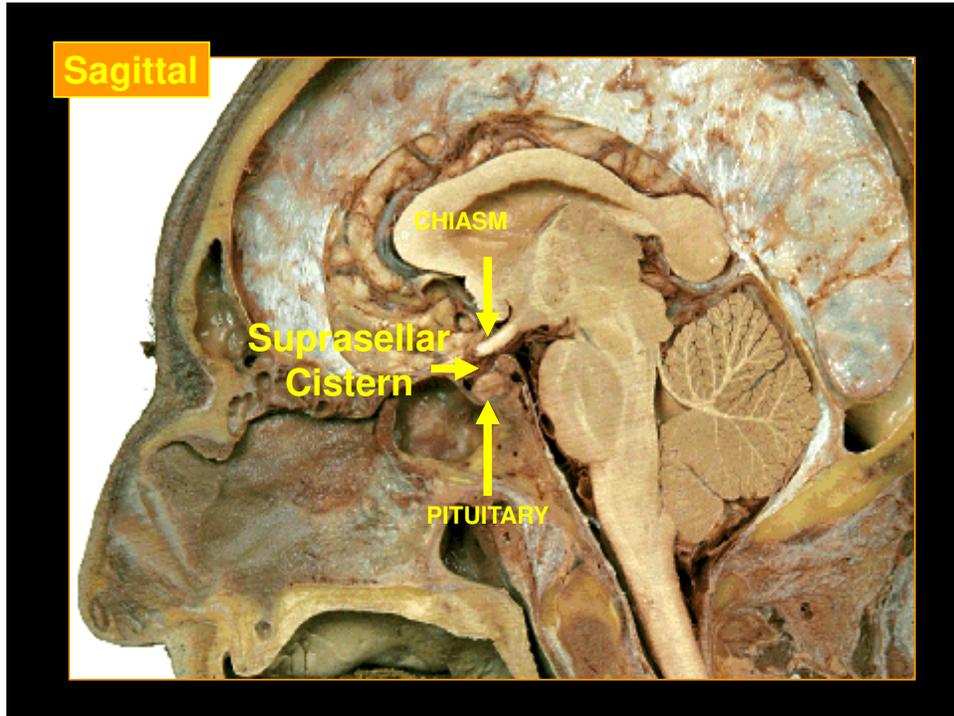


Lawrence G. Gray, OD

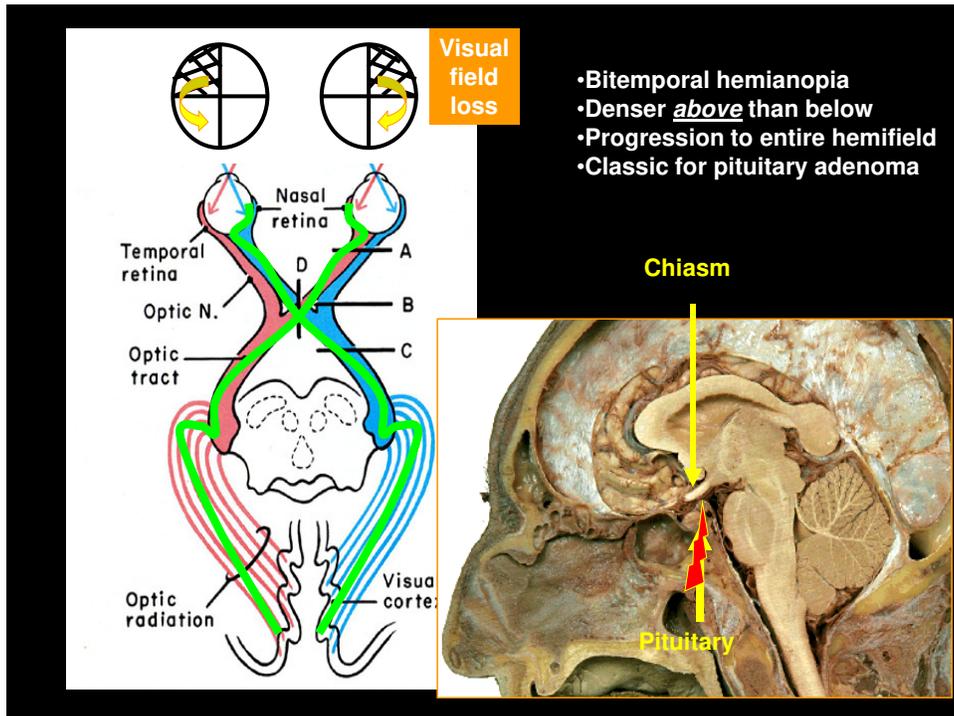
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94

The diagram illustrates the visual pathway from the retina to the visual cortex. At the top, two circular diagrams show visual field loss patterns. The main diagram labels the Temporal retina, Nasal retina, Optic N., Optic tract, Optic radiation, and Visu cort. A red arrow points to the chiasm in a brain specimen on the right.

**Visual field loss**

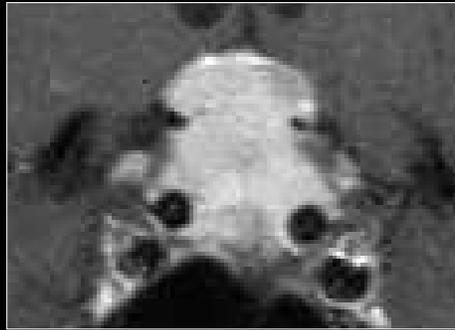
- Posterior chiasmal lesions (pressure from above) denser below than above
- Produce bitemporal hemianopia with highest density pointing toward fixation

95

# Lesions of the Chiasm

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## Pituitary Adenomas



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## Pituitary Adenoma

- Benign tumors of pituitary origin
- Third most common intracranial tumor (25% prevalence at autopsy/MRI)
- Micro vs. macroadenoma (>10mm)
- Secretory (prolactin) vs. non-secretory
- Localized (2/3) vs. invasive (1/3)
- Do not produce papilledema

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## Pituitary Adenoma (cont.)

- MRI findings:
  - Iso-intense to brain
  - homogeneous staining with gadolinium (highly vascularized)

109

## Pituitary Adenoma (cont.)

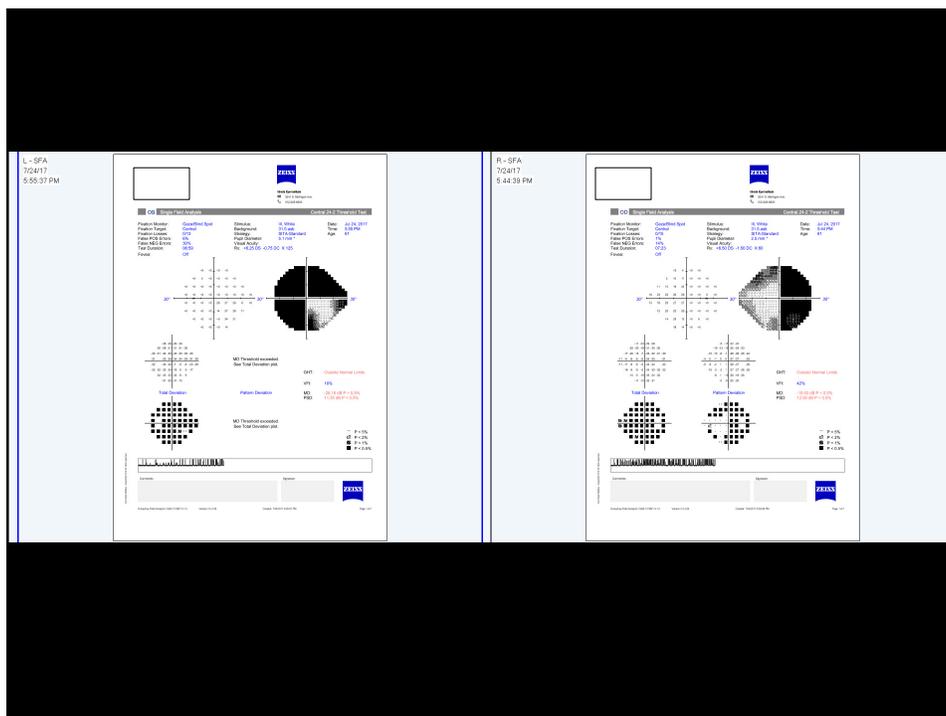
- Complications:
  - Endocrine dysfunction
  - Pituitary apoplexy
  - Vision!!

110

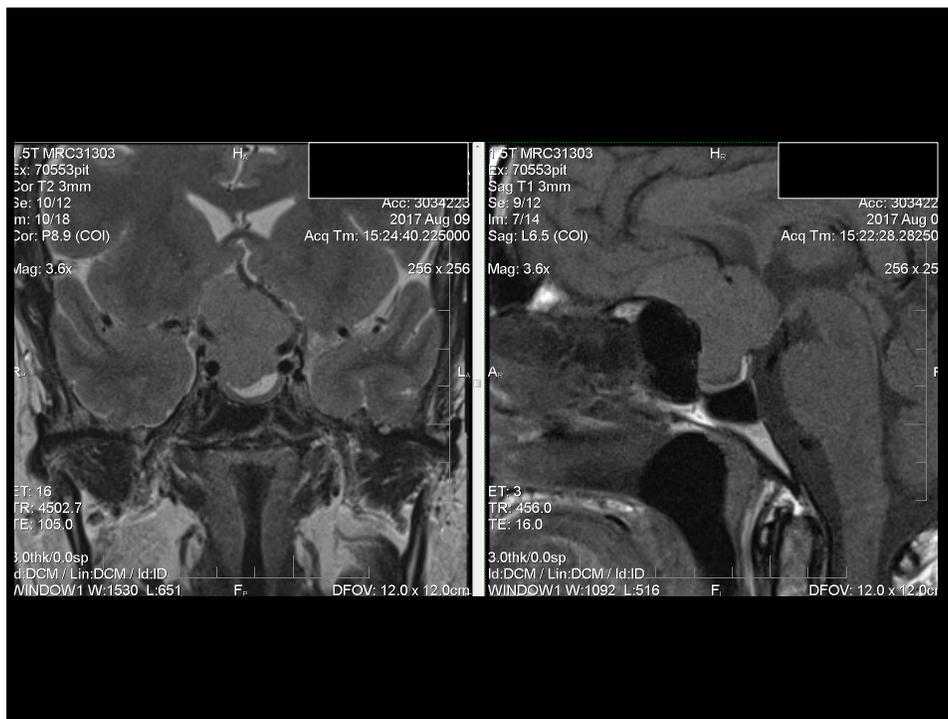
## 61 Y/O Hispanic Woman

- C/o progressive vision loss, both eyes
- Approx. 2 years duration
- BVA:
  - 20/40 OD
  - 20/70 OS

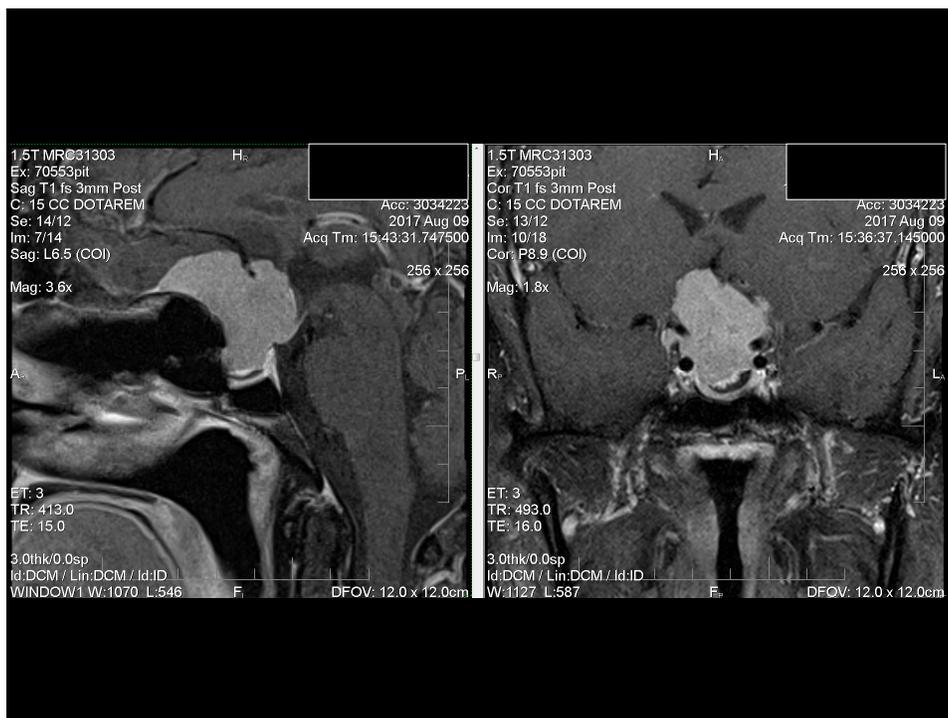
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112



113



114

 CrossMark

### Optical coherence tomography retinal ganglion cell complex analysis for the detection of early chiasmal compression

Richard J. Blanch<sup>1,2,3</sup> · Jonathan A. Miceli<sup>1</sup> · Nelson M. Oyesiku<sup>4</sup> · Nancy J. Newman<sup>1,4,5</sup> · Valérie Biousse<sup>1,5</sup>

Published online: 10 August 2018  
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**Abstract**

**Purpose** To report patients with sellar tumors and chiasmal compression with normal visual fields, who demonstrate damage to the retinal nerve fiber layer (RNFL) and ganglion cell complex (GCC) on optical coherence tomography (OCT).

**Methods** Seven patients with sellar tumors causing mass effect on the optic chiasm without definite visual field defect, but abnormal GCC are described. GCC/RNFL analyses using Cirrus-OCT were classified into centiles based on the manufacturer's reference range.

**Results** In seven patients with radiologic compression of the chiasm by a sellar tumor, OCT-GCC thickness detected compressive chiasmopathy before visual defects became apparent on standard automated visual field testing. Without OCT, our patients would have been labelled as having normal visual function and no evidence of compressive chiasmopathy. With only OCT-RNFL analysis, 3/7 patients would still have been labelled as having no compression of the anterior visual pathways.

**Conclusions** These patients show that OCT-GCC analysis is more sensitive than visual field testing with standard automated perimetry in the detection of compressive chiasmopathy or optic neuropathy. These cases and previous studies suggest that OCT-GCC analysis may be used in addition to visual field testing to evaluate patients with lesions compressing the chiasm.

**Keywords** Pituitary adenoma · Sellar mass · Chiasmal compression · Optic neuropathy · Visual field test · Optical coherence tomography · Ganglion cell complex analysis

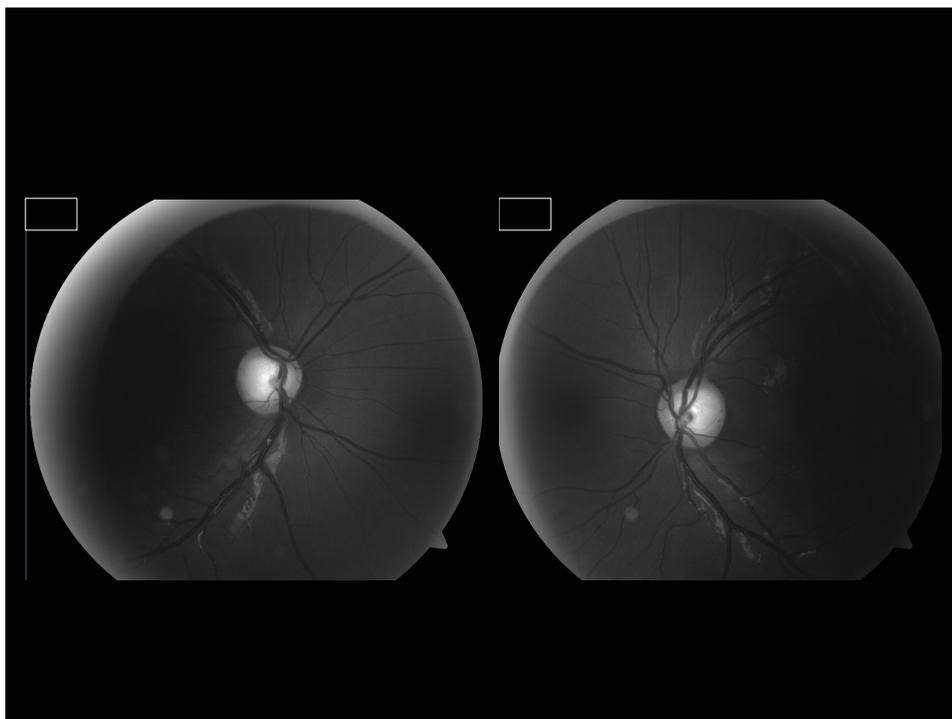
Blanch RJ, et al. *Pituitary* 2018

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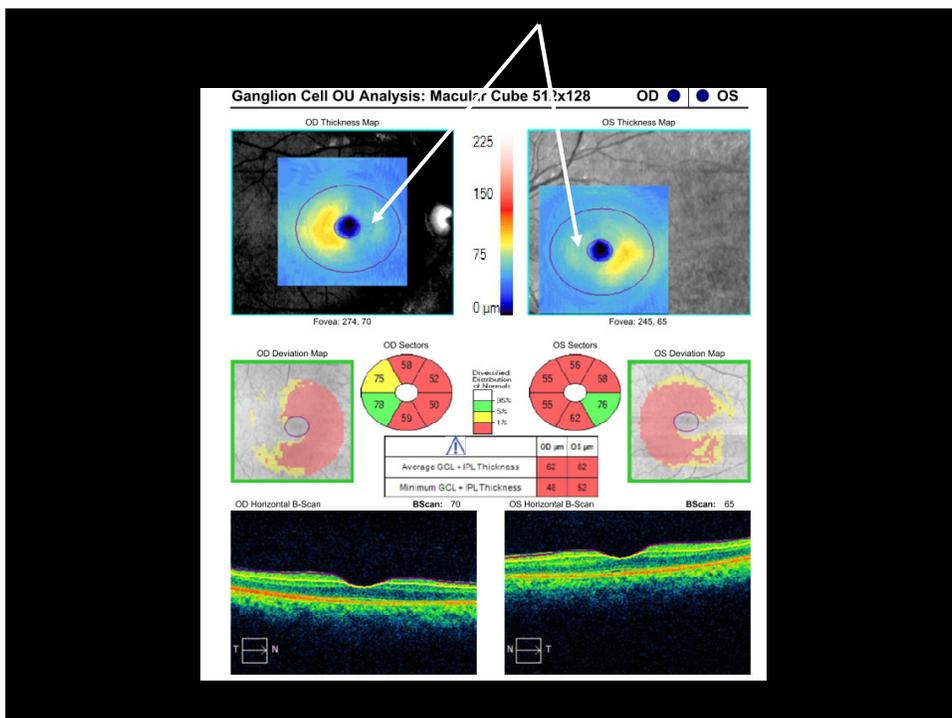
## 18 Y/O AA Man

- C/o vision loss OS 1-2 years ago
- Vision OD is “perfect”
- BVA:
  - 20/20 OD
  - 20/500 OS

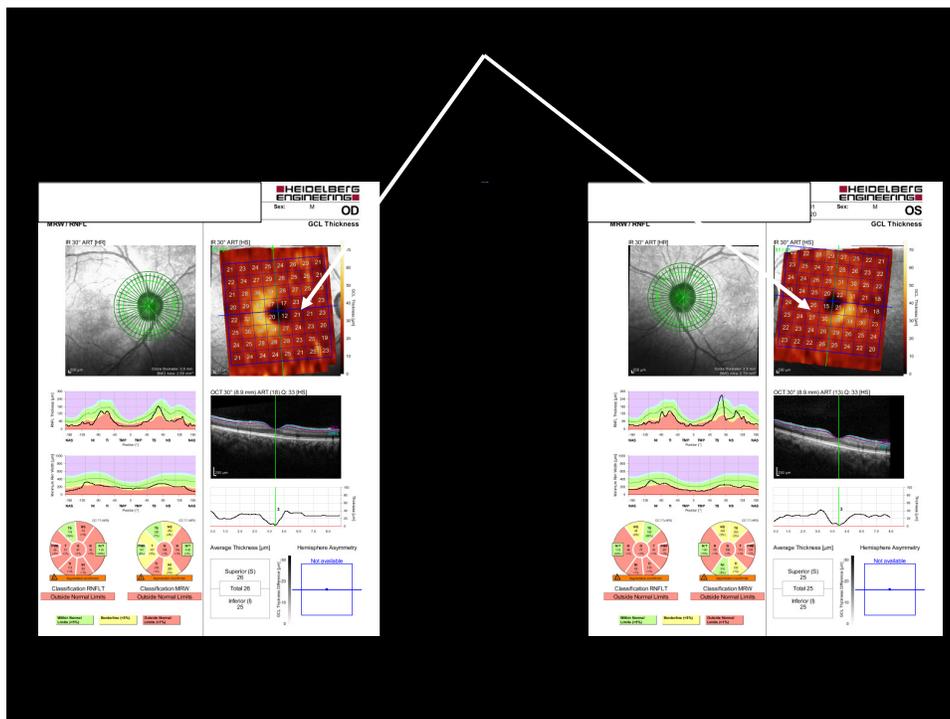
122



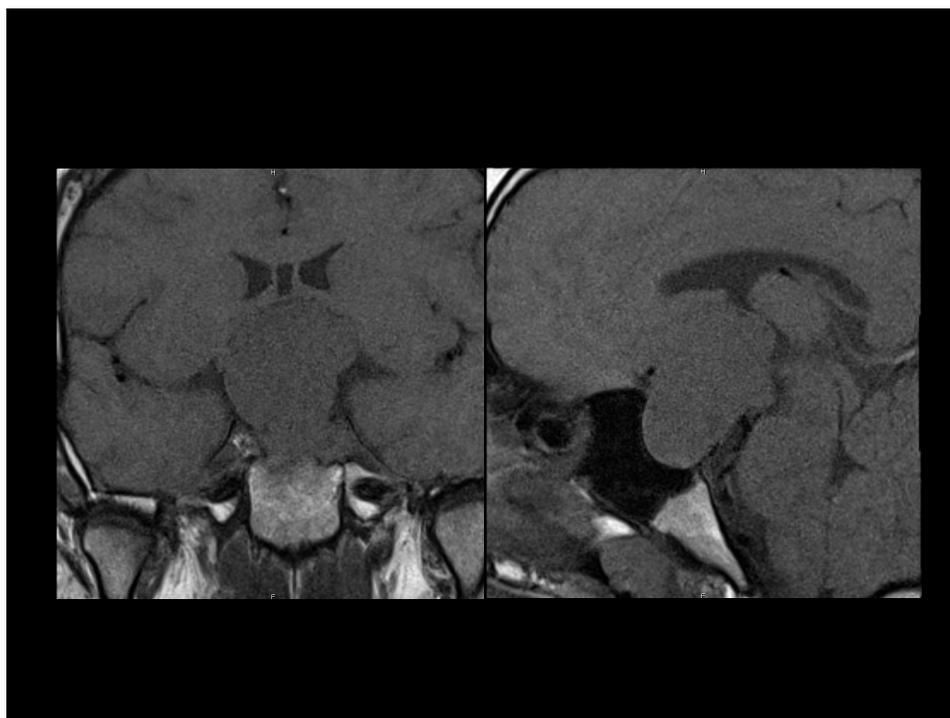
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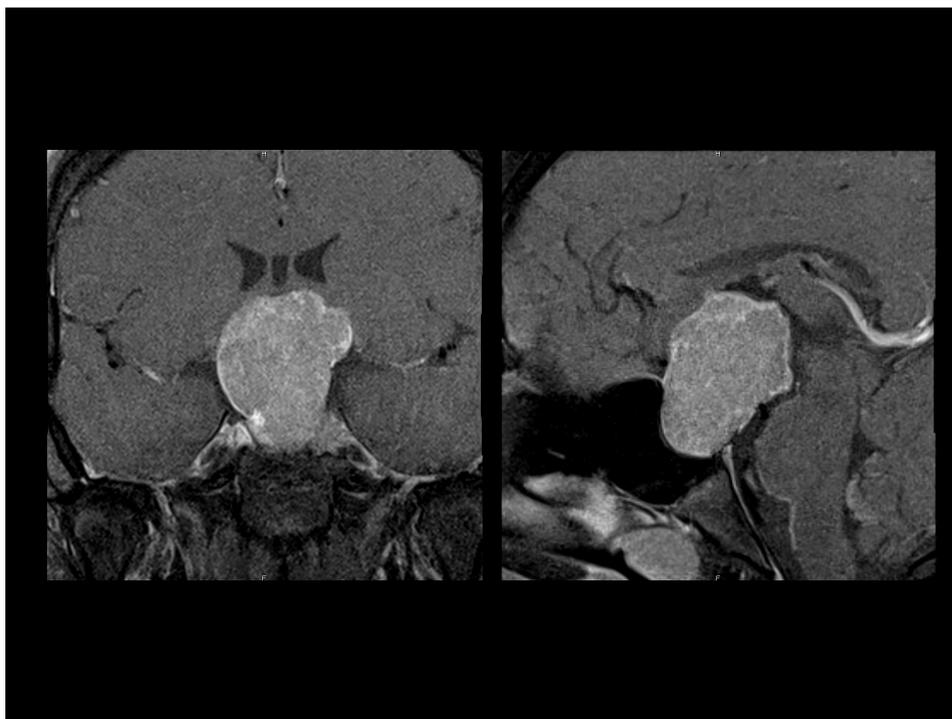
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125



126



127

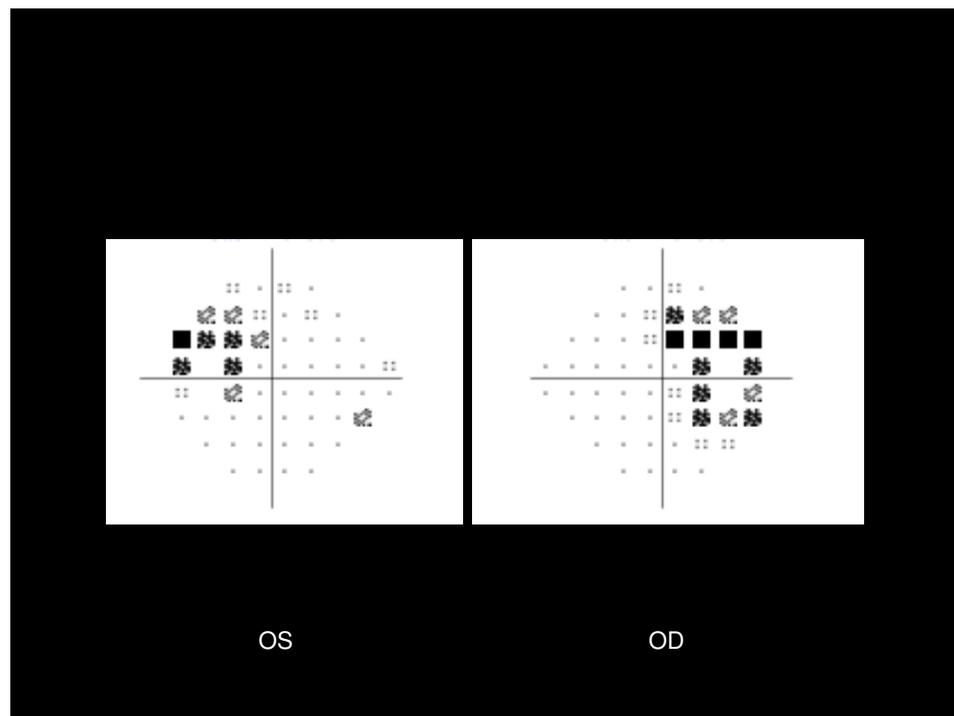
**Not all bitemporal defects are due to chiasmal disease...**

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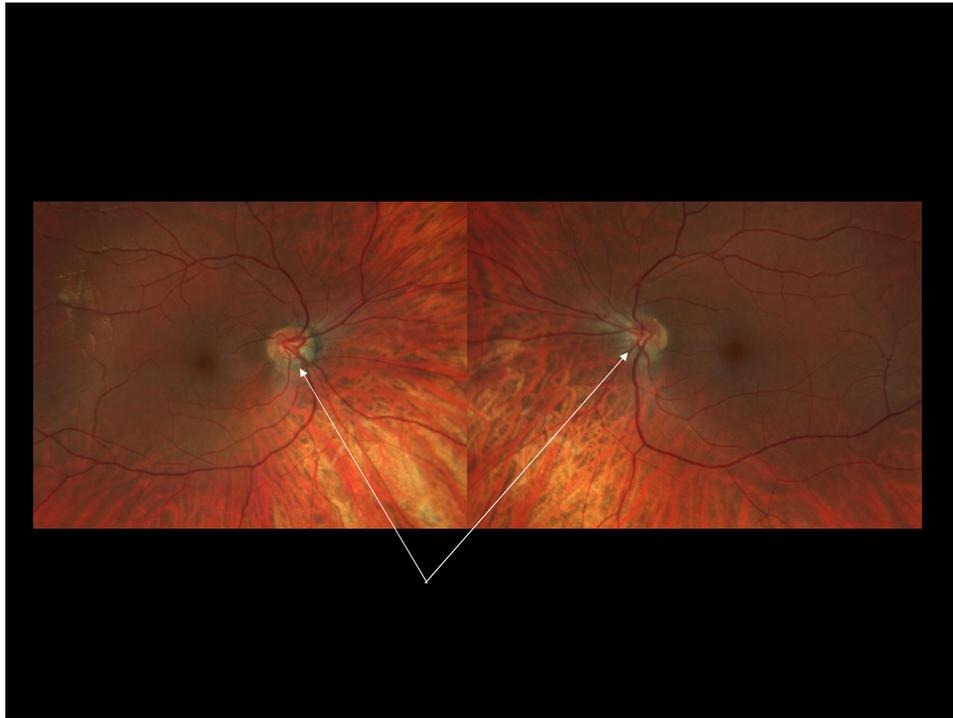
## 27 Y/O Caucasian Man

- Suspicion of chiasmal compression
- Moderate-high myopia
- BVA:
  - 20/20 OD
  - 20/20 OS

129



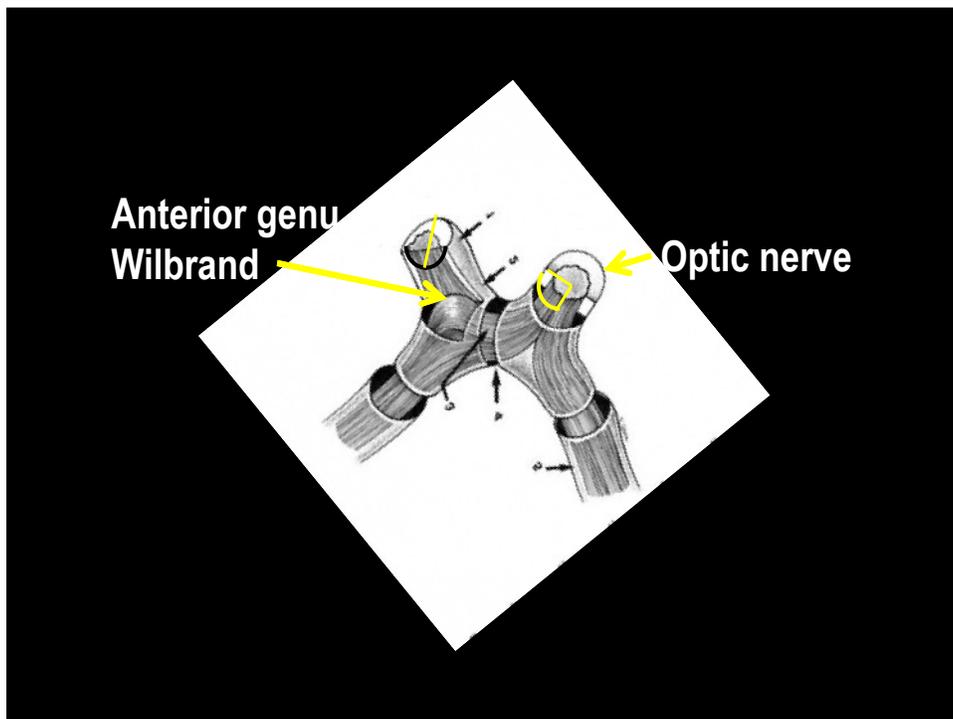
130



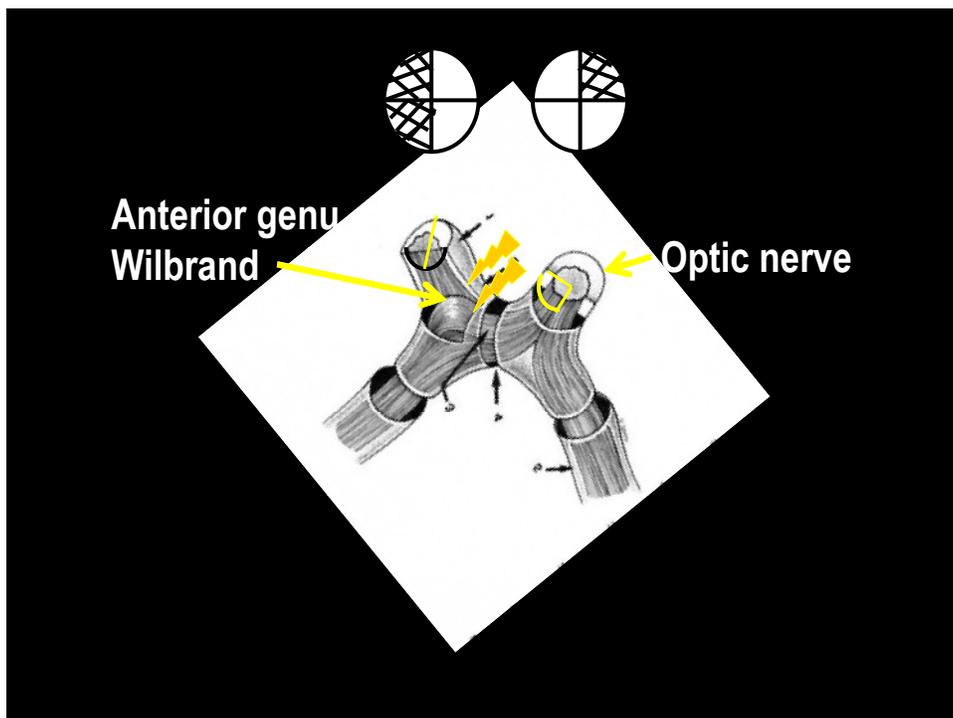
131

## Anterior Chiasmal Syndrome

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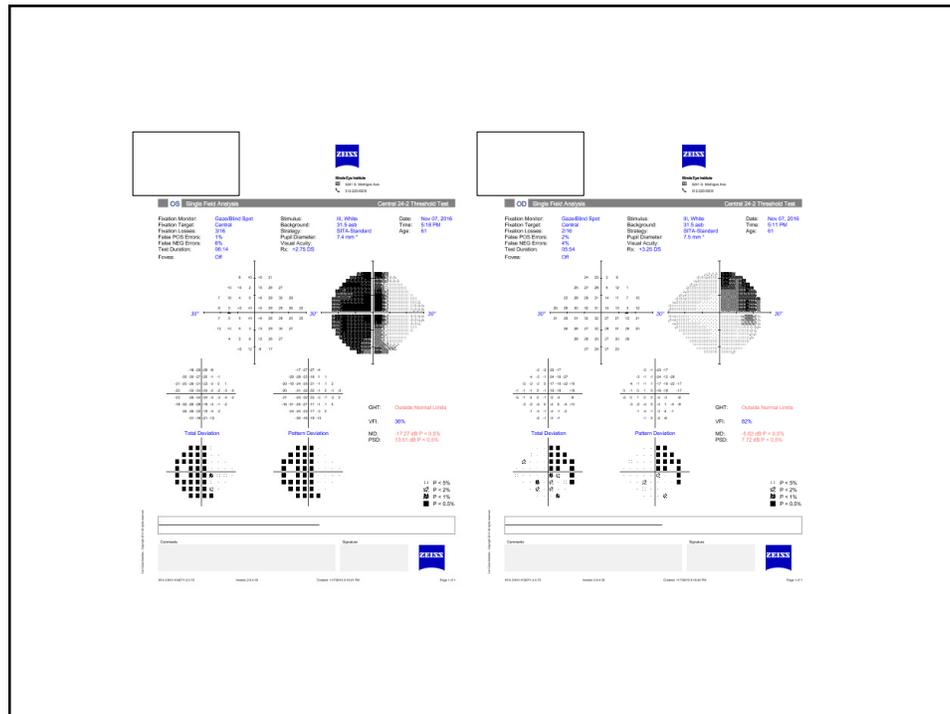


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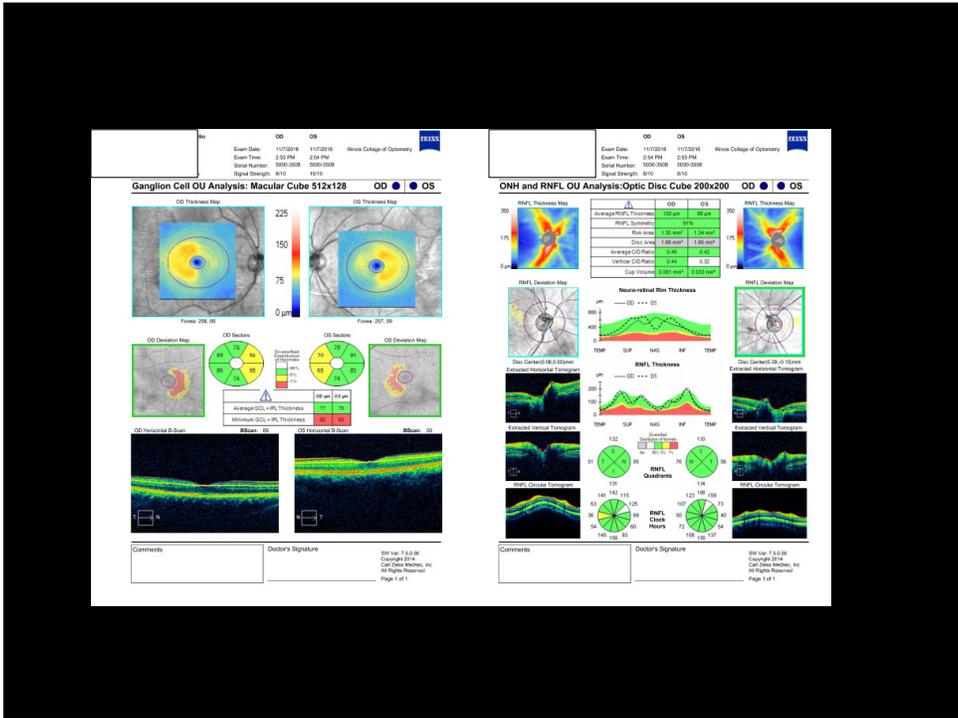
# 61 Y/O Hispanic Man

- C/o progressive vision loss, OS
  - Several months duration
- Long-standing history of DM / HTN
- Conf fields:
  - Temp field loss denser above, OD
  - Complete temp field loss, OS
- BVA:
  - 20/20 OD
  - 20/400 OS

135



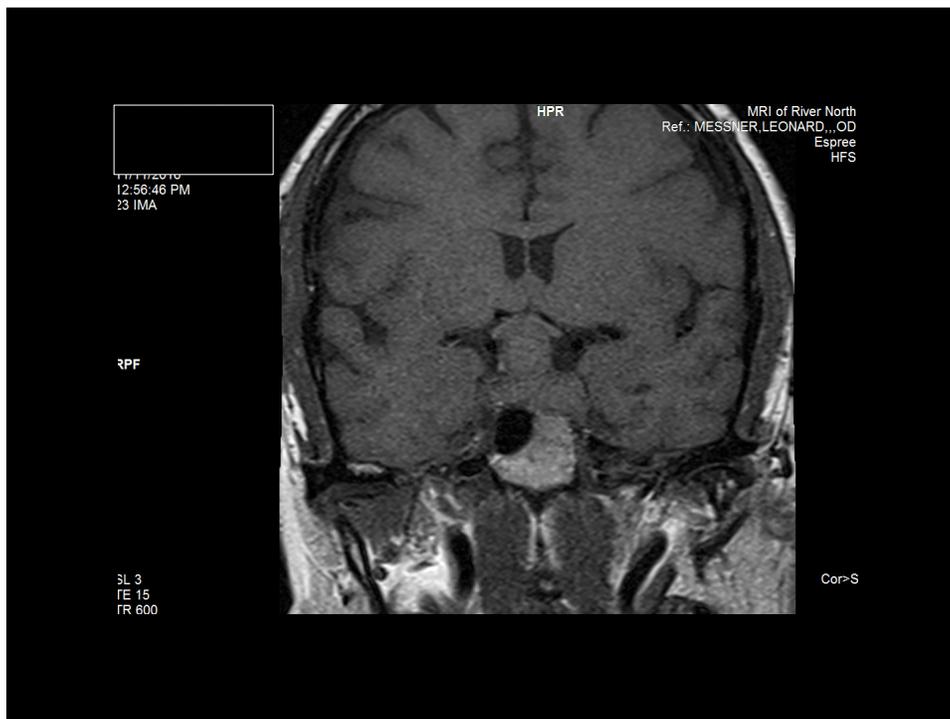
136



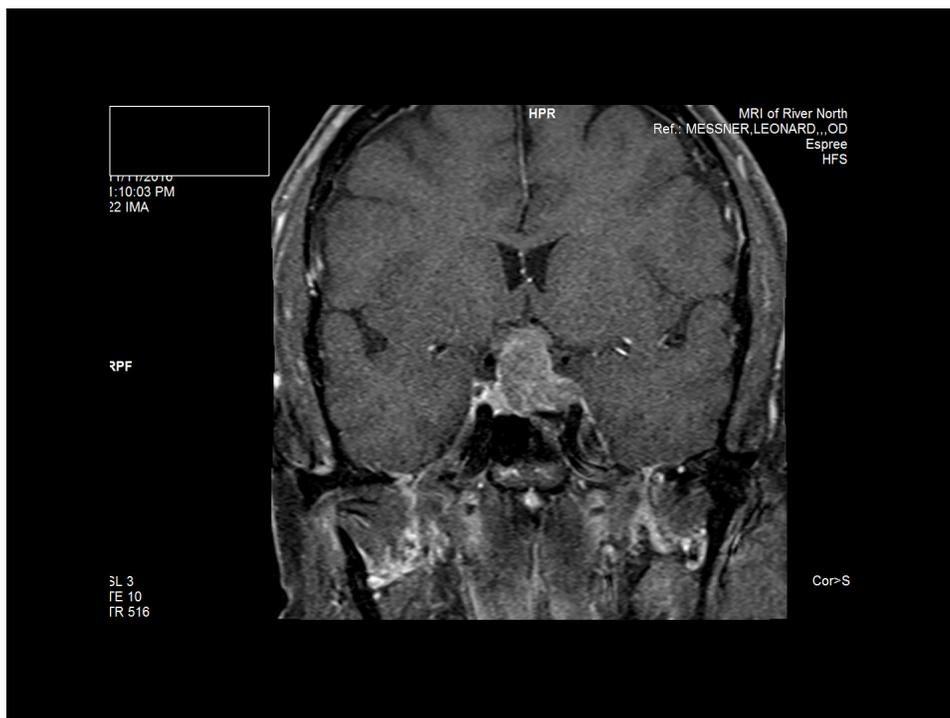
137



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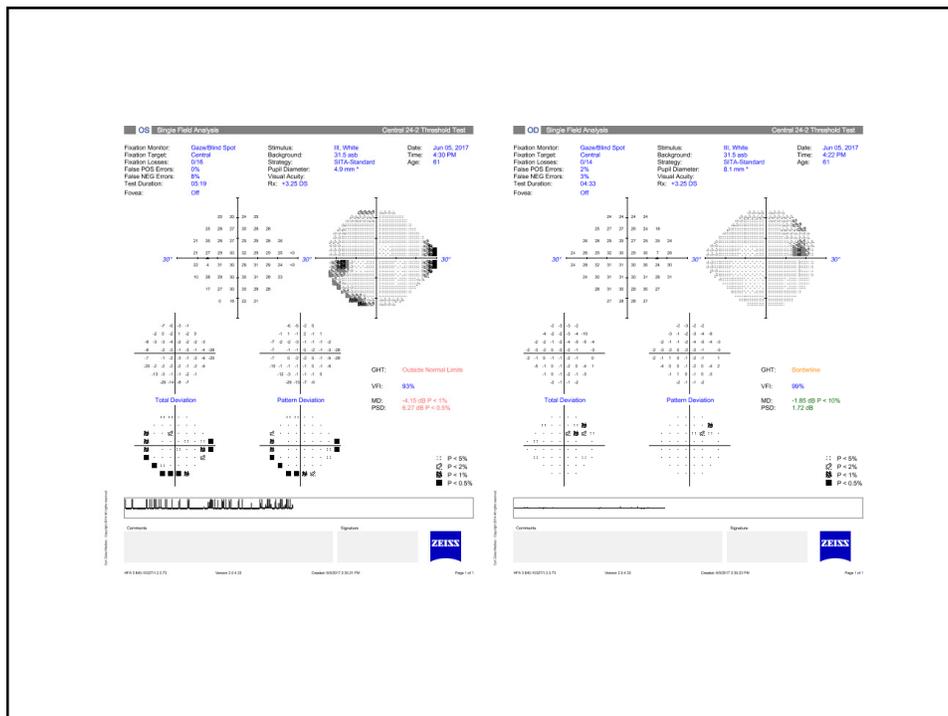


140

# S/P Trans-sphenoidal Resection of Tumor

- BVA:
  - 20/20 OD
  - 20/20 OS

141

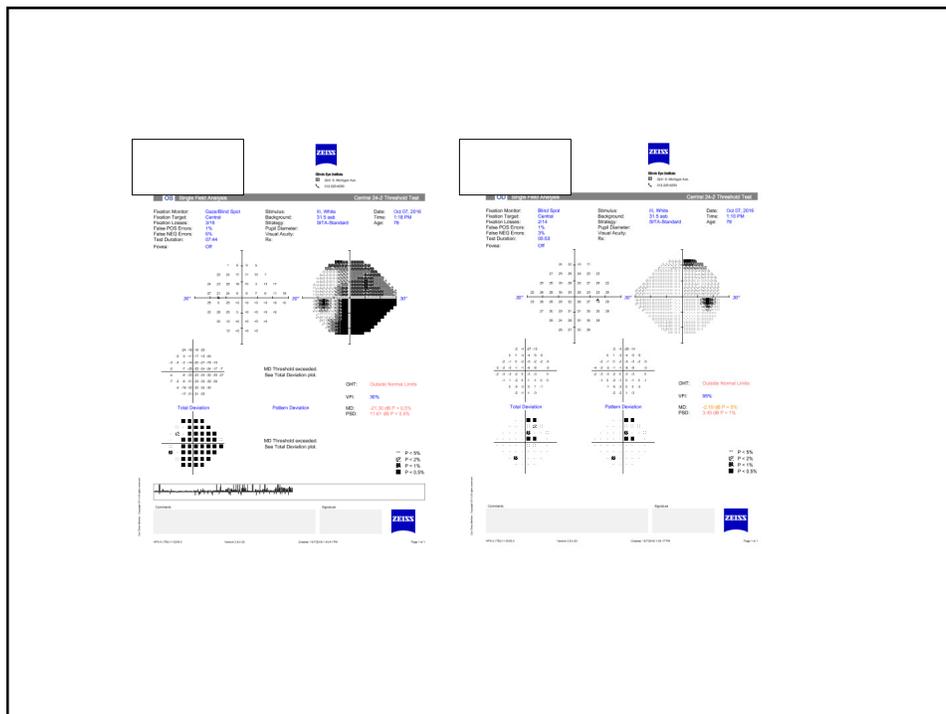


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## 79 y/o AA Man

- C/o progressive vision loss OS x several years
- BVA:
  - 20/20 OD
  - 20/60 OS

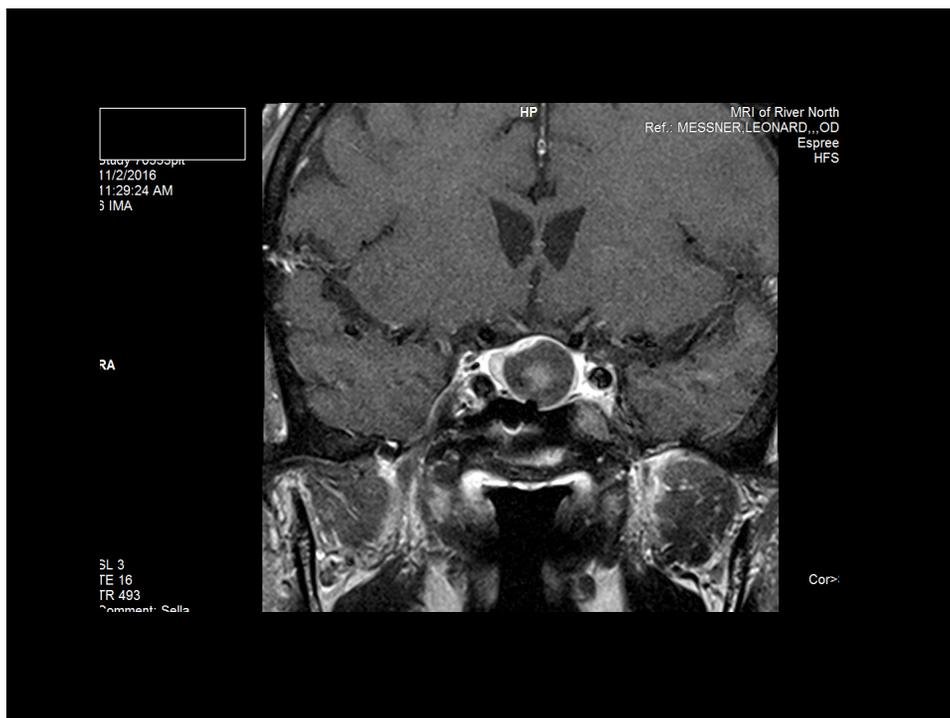
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145

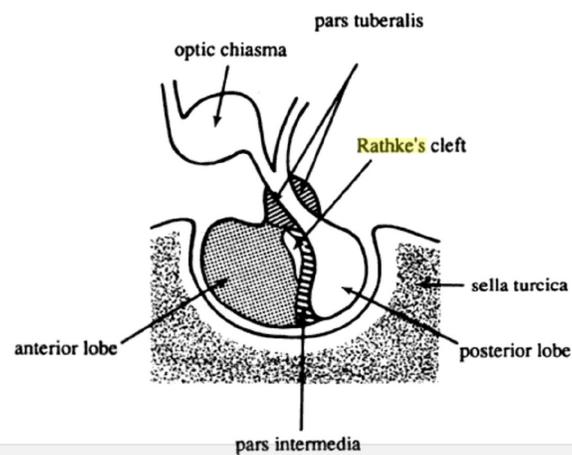


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## Rathke's Cleft Cyst

- Benign, cystic tumors from embryonic remnant of Rathke pouch (33% of autopsy specimens)
- Often with mucin-derived nodule (iso/hyperintense to brain)
- Trans-sphenoidal drainage vs. extirpation
- Variable recurrence

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**Fig. 2:** A diagram to show the location of Rathke's cleft which can give rise to Rathke's cleft cyst.

© Surgical Pathology of the Head and Neck, Volume 3 By Leon Barnes

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## Invasive Pituitary Adenomas

- 35% of all pituitary adenomas
- Invasion of parasellar regions:
  - Vascular (cavernous sinus)
  - Neural tissues
  - Bone
- Rapid growth/early recurrence (within 6 months of removal)

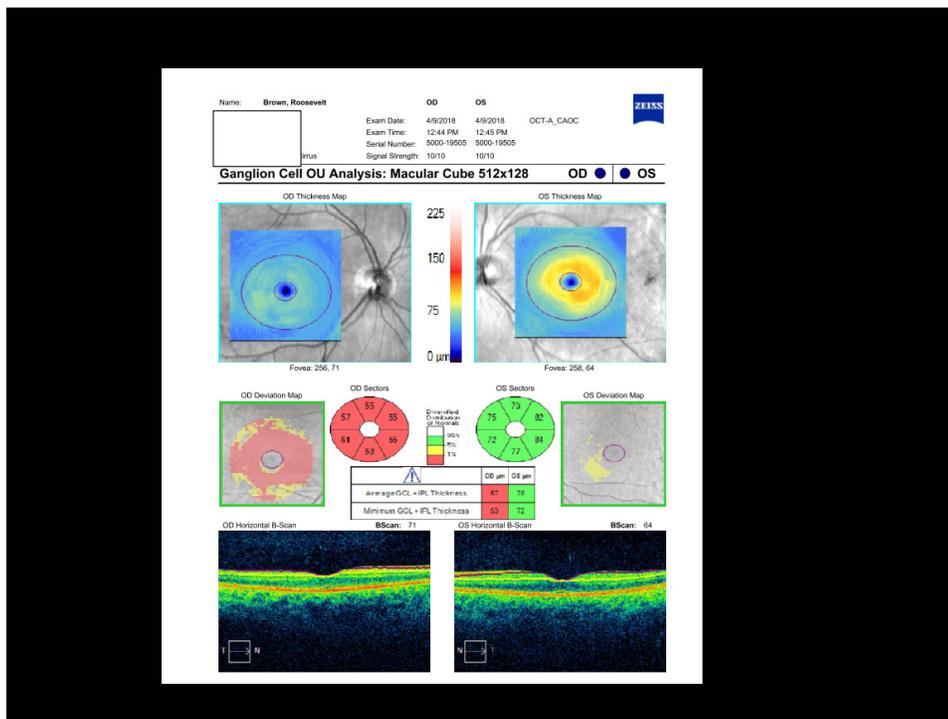
Moldovan IA, et al. *Romanian Neurosurg* 2016

149

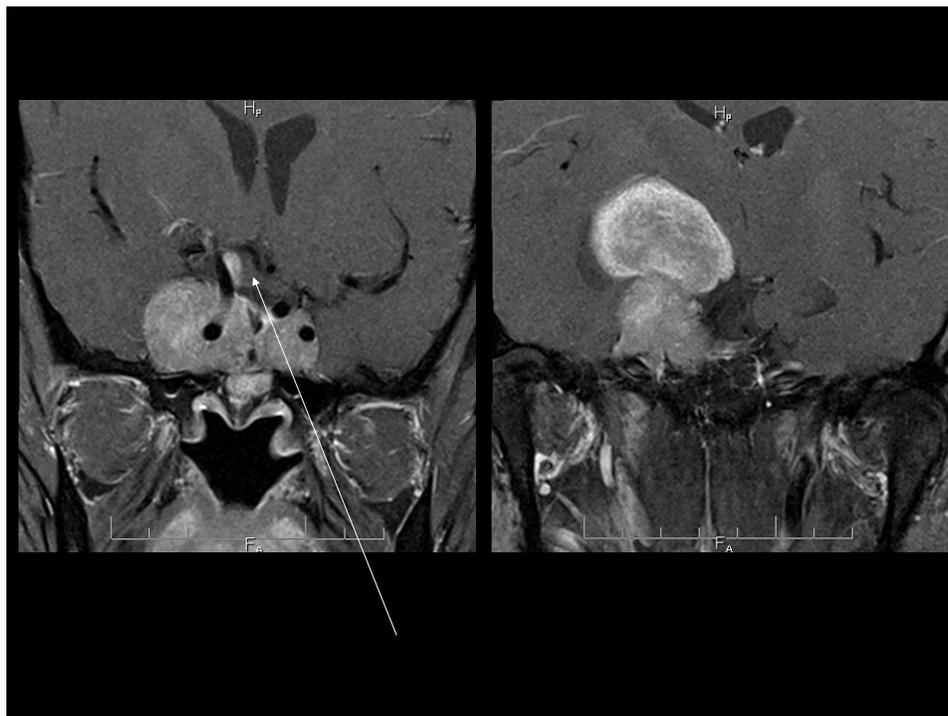
## 44 y/o AA Man

- Progressive vision loss OD x 4 years
- s/p trans-sphenoidal resection of “pituitary mass” in 2014
- BVA:
  - HM OD
  - 20/30 OS

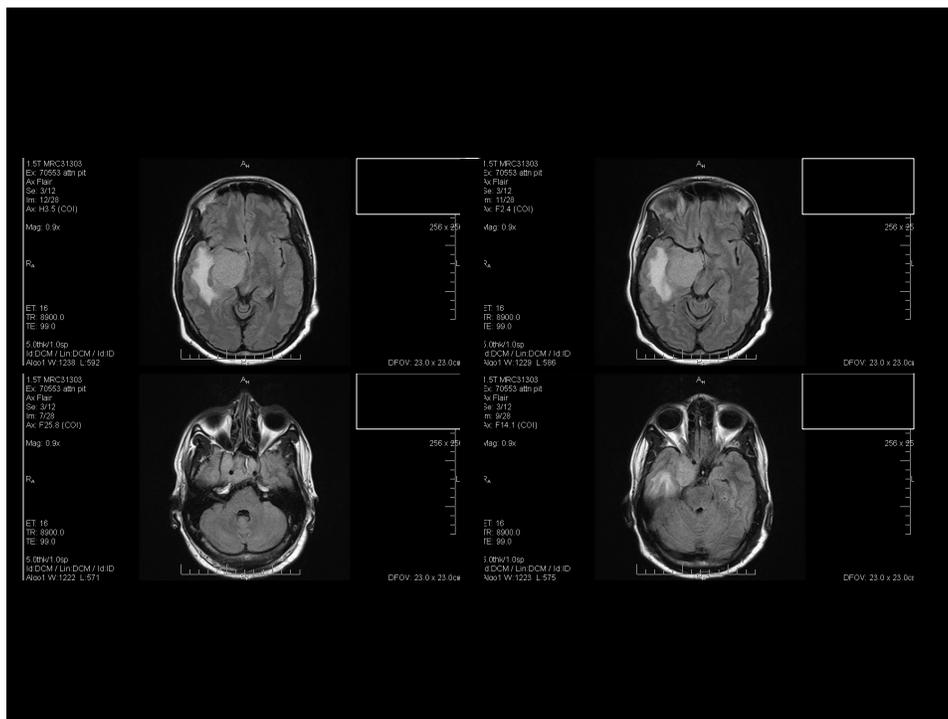
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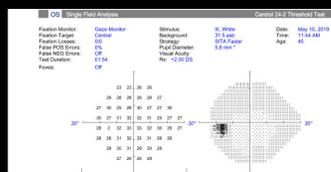
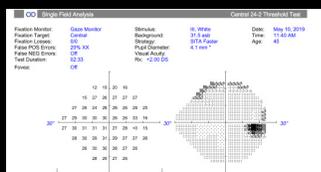
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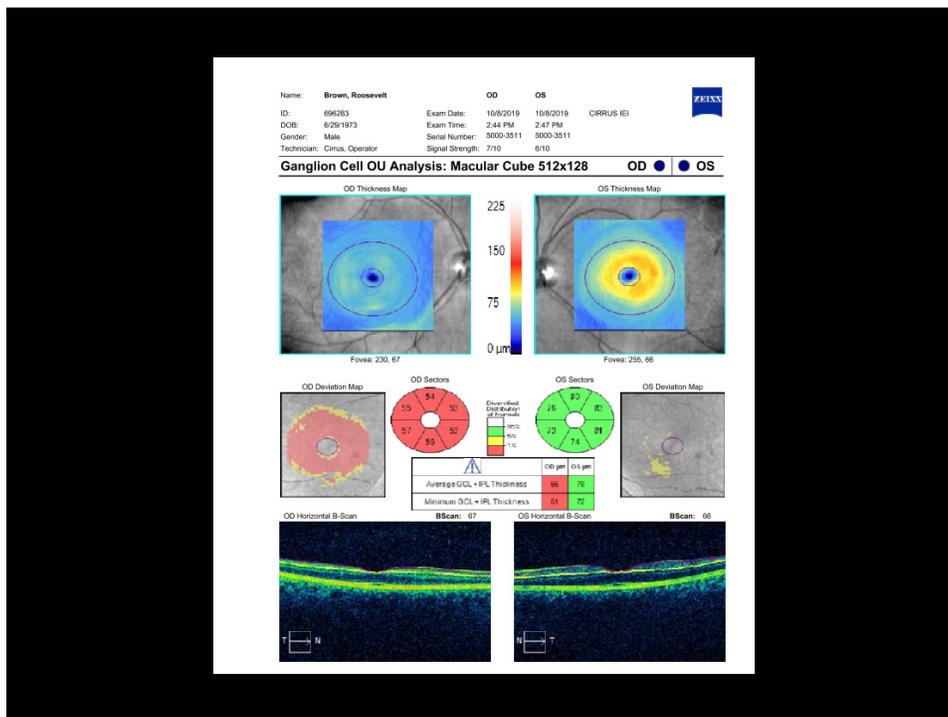
153

### 3 months s/p surgical resection of tumor

- BVA:
  - 20/25 OD
  - 20/20 OS



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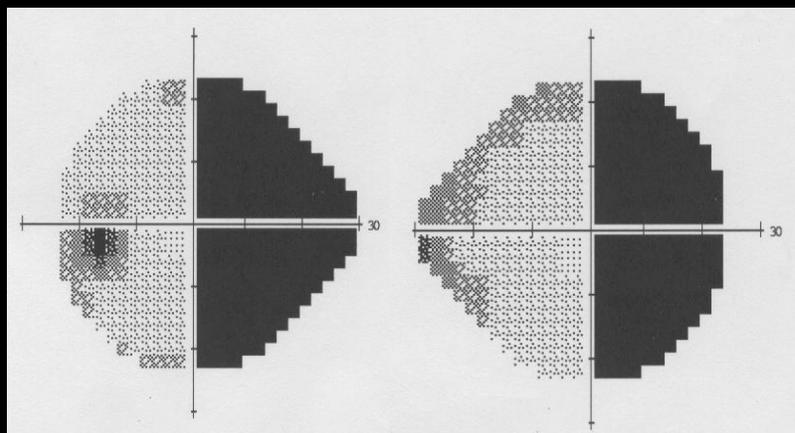
# Retro-chiasmal Lesions

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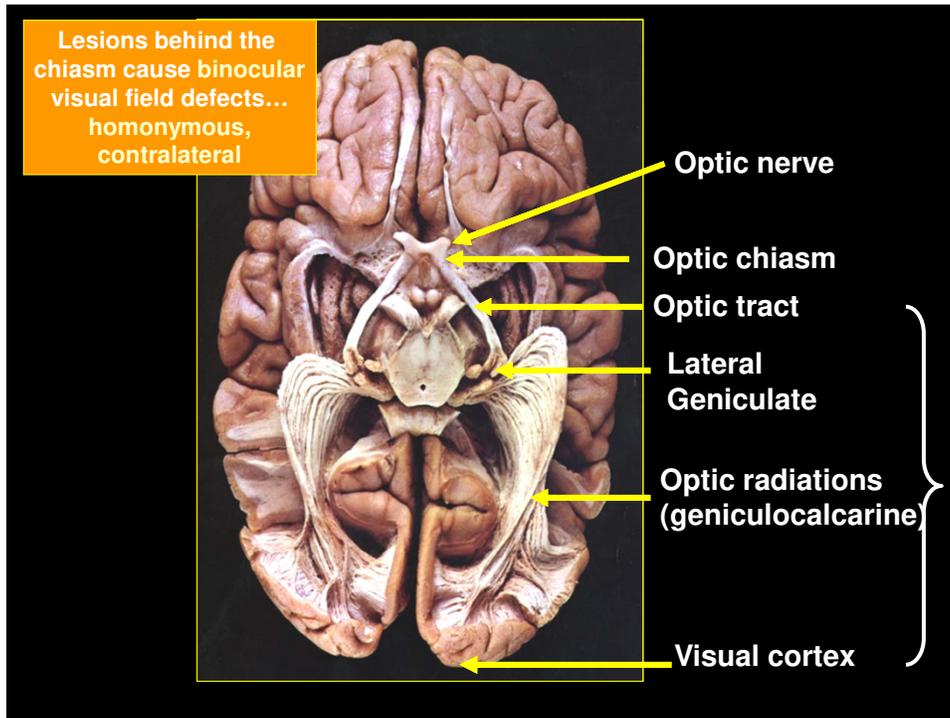
## 70 y/o AA Woman

- C/o progressive difficulty seeing objects to her right x 4 months
- BVA:
  - 20/20 OD
  - 20/20 OS

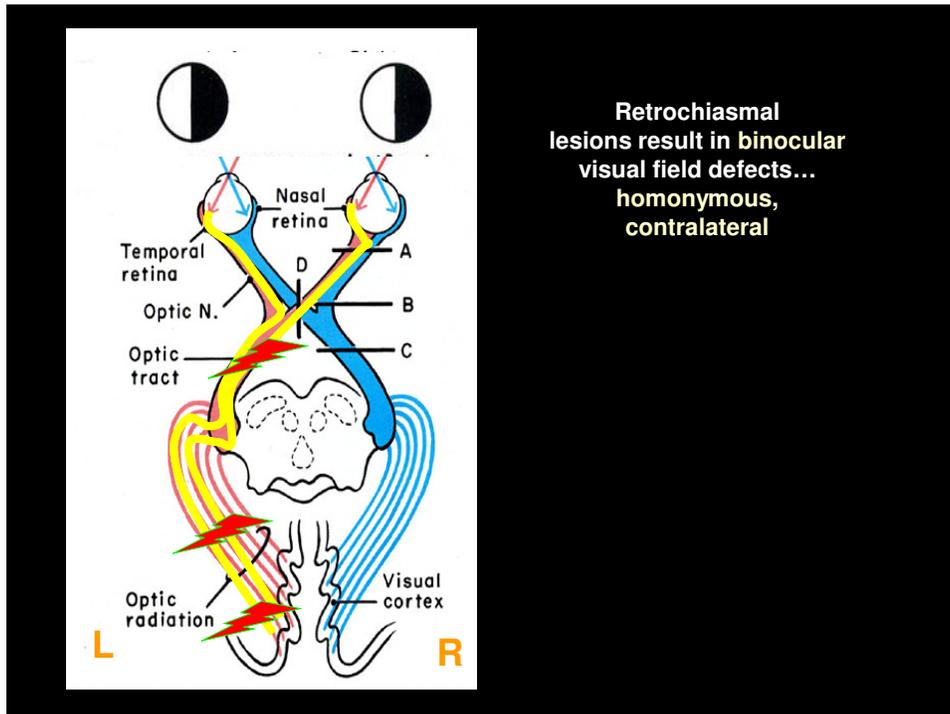
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**Temporal lobe lesion**

**Inferior retinal quadrants**

**Related neurologic problems:**  
Memory/auditory dysfunction, seizures

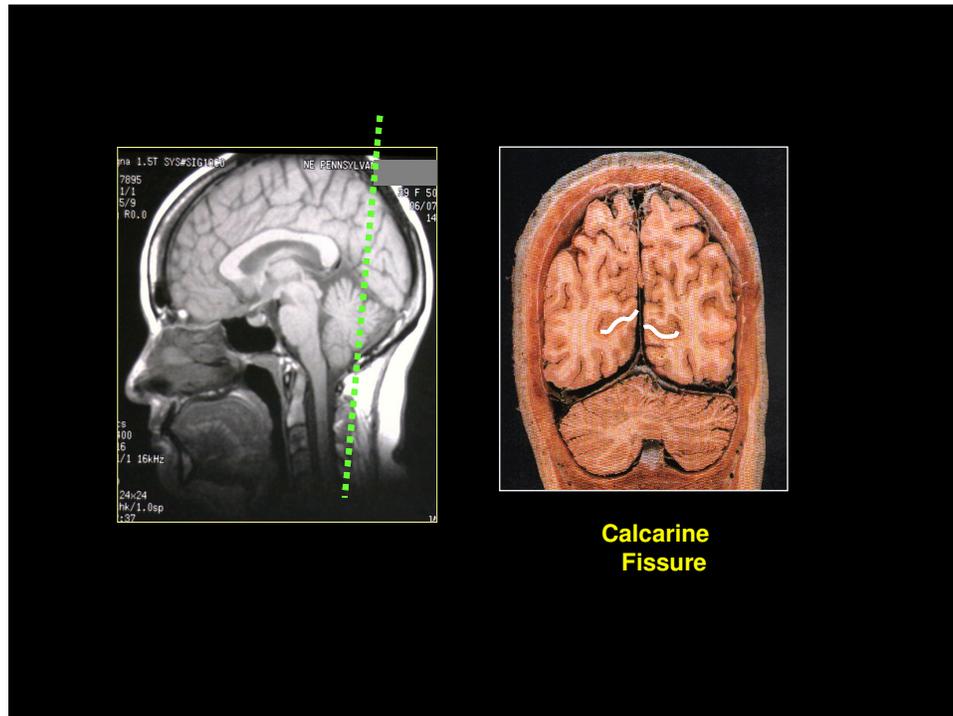
161

**Parietal lobe lesion**

**superior retinal quadrants**

**Related neurologic problems:**  
Neglect of non-dominant side, agnosia, apraxia, math difficulty, abn. saccades

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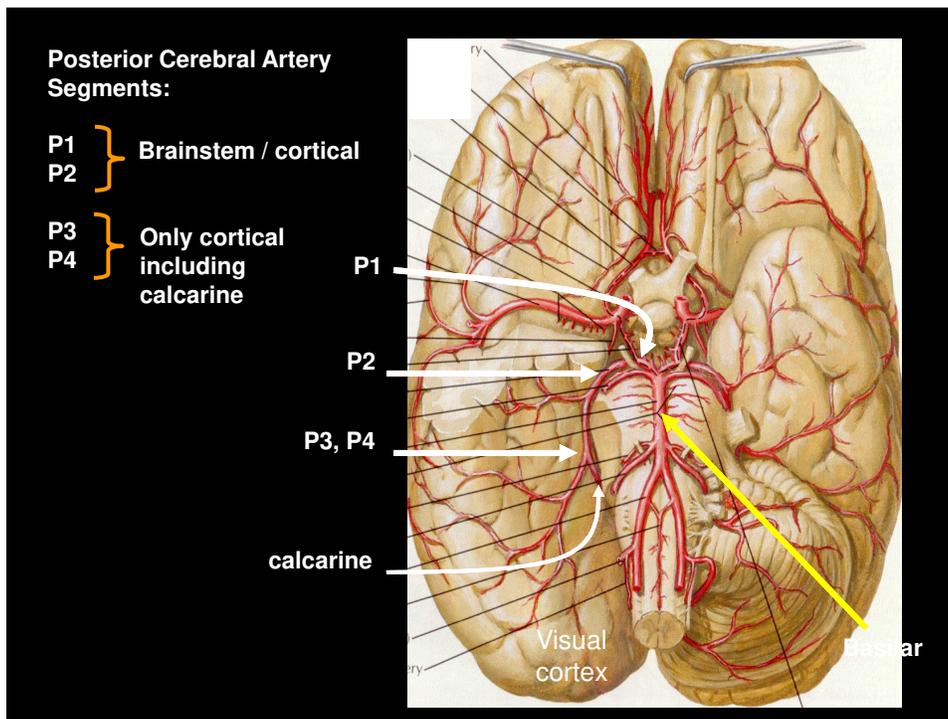


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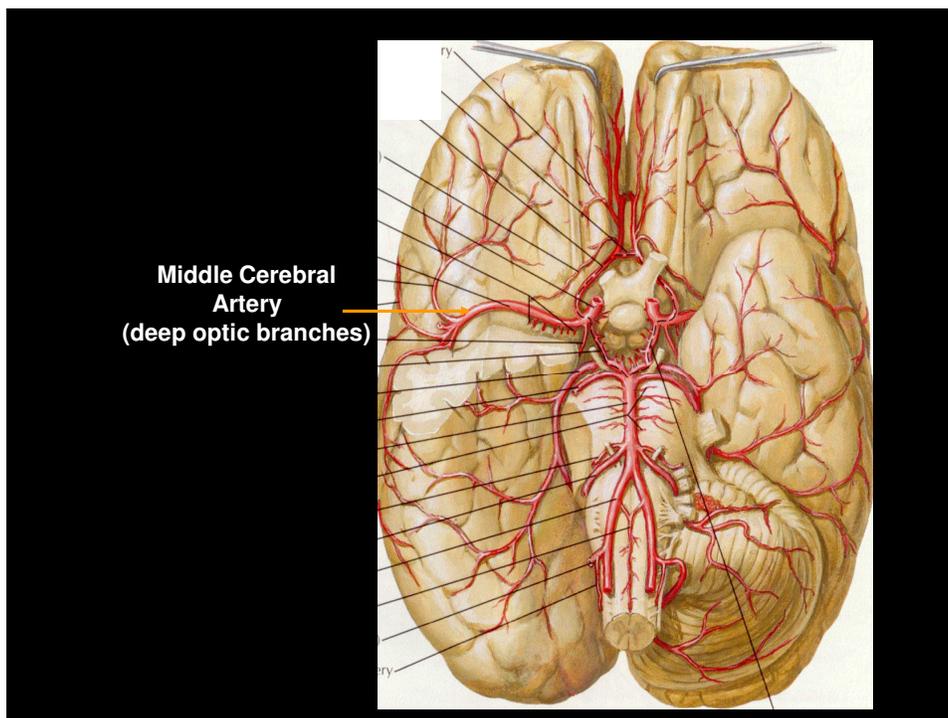
## Blood Supply to Occipital Lobes

- P3/P4 branches of the posterior cerebral artery (medial aspect)
  - Calcarine branch
  - Posterior lateral PCA branch
- Middle cerebral artery (lateral aspect)
  - deep optic branches

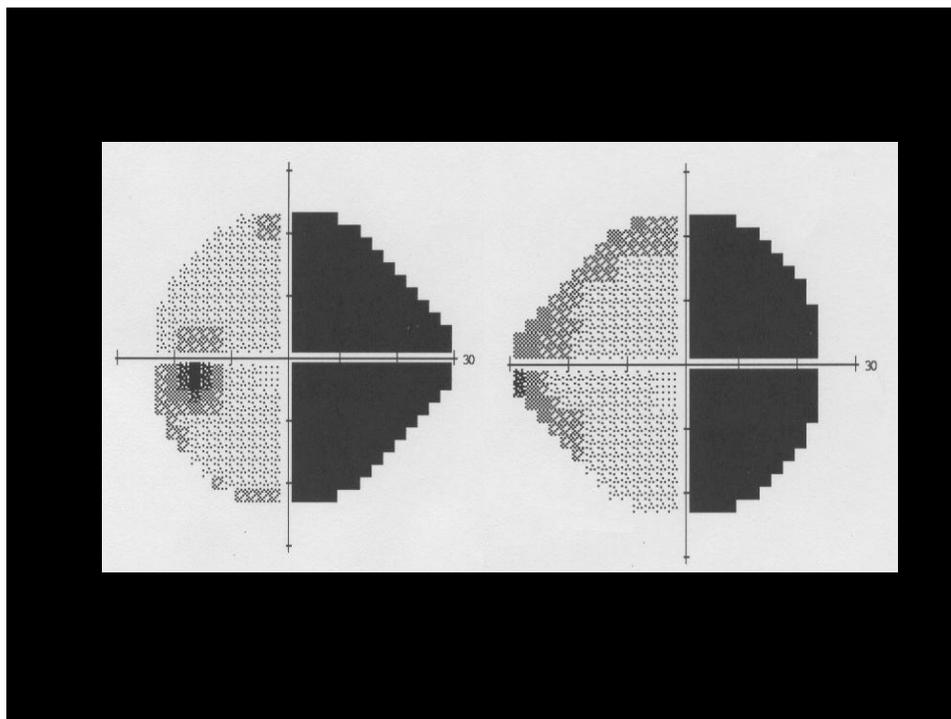
164



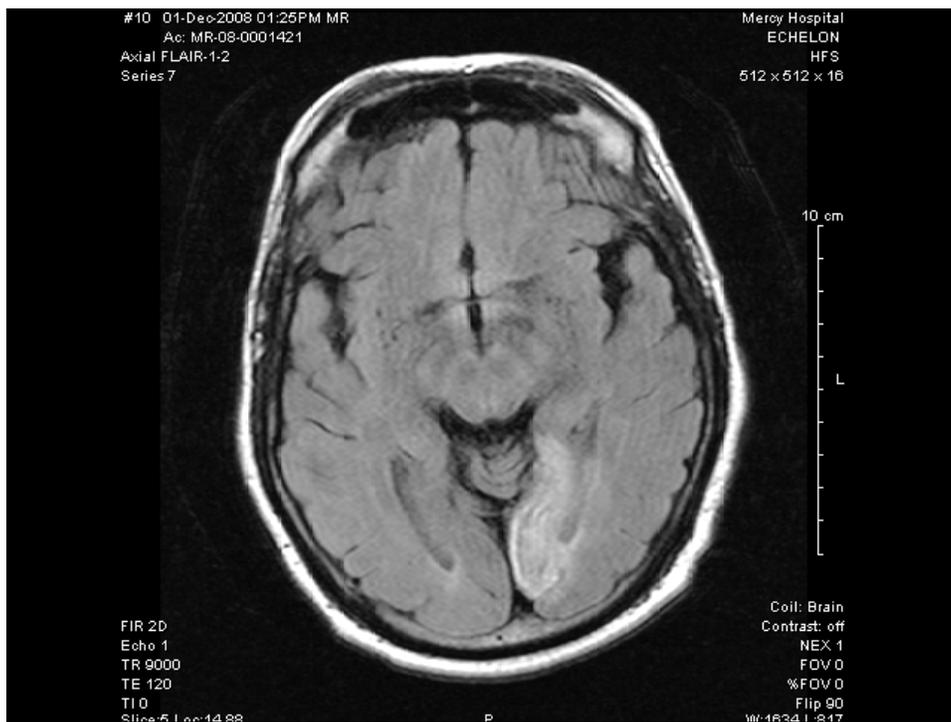
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## Posterior Cerebral Artery Infarction

- 5-10% of cerebral infarcts
- 5% stroke-related death (P1 & P2 segments)
- *84% chronic visual field defects (P3 & P4 segments)*

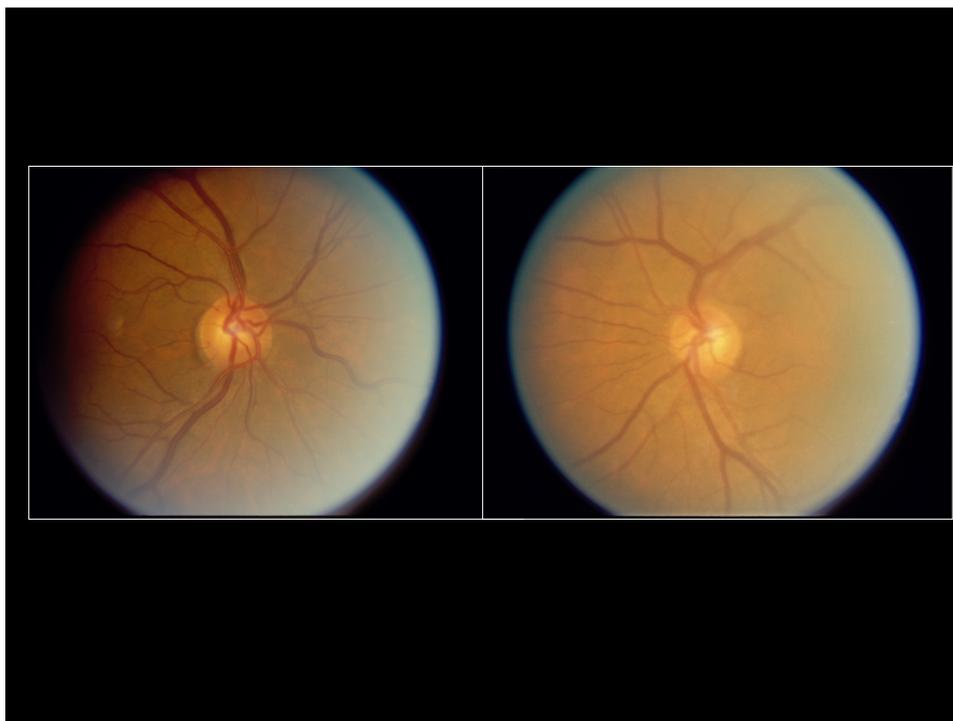
Brandt T, et al. *Cerebrovasc Dis* 2000

169

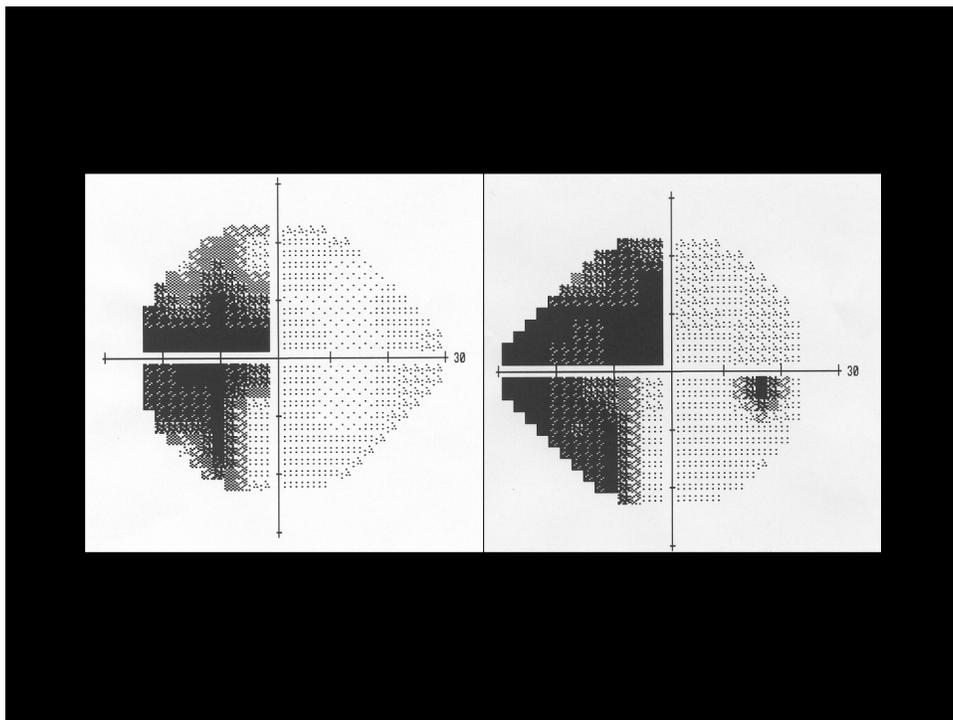
## A 58-y/o Man

- C/o recent onset vision loss on left side
- BVA: 20/20 OU
- PMI: HTN x 20 years

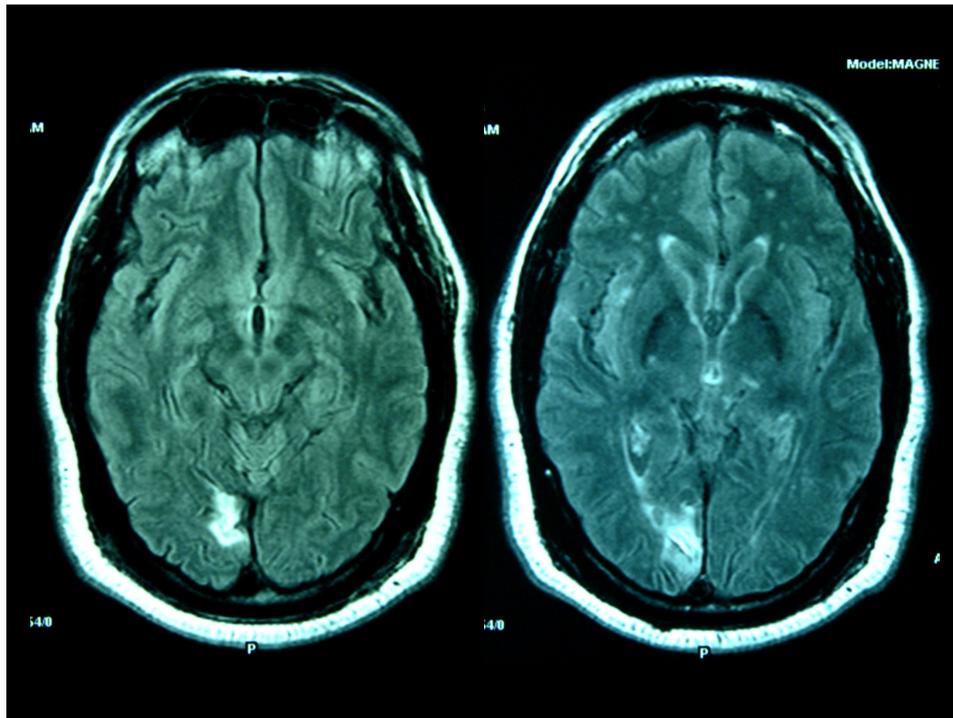
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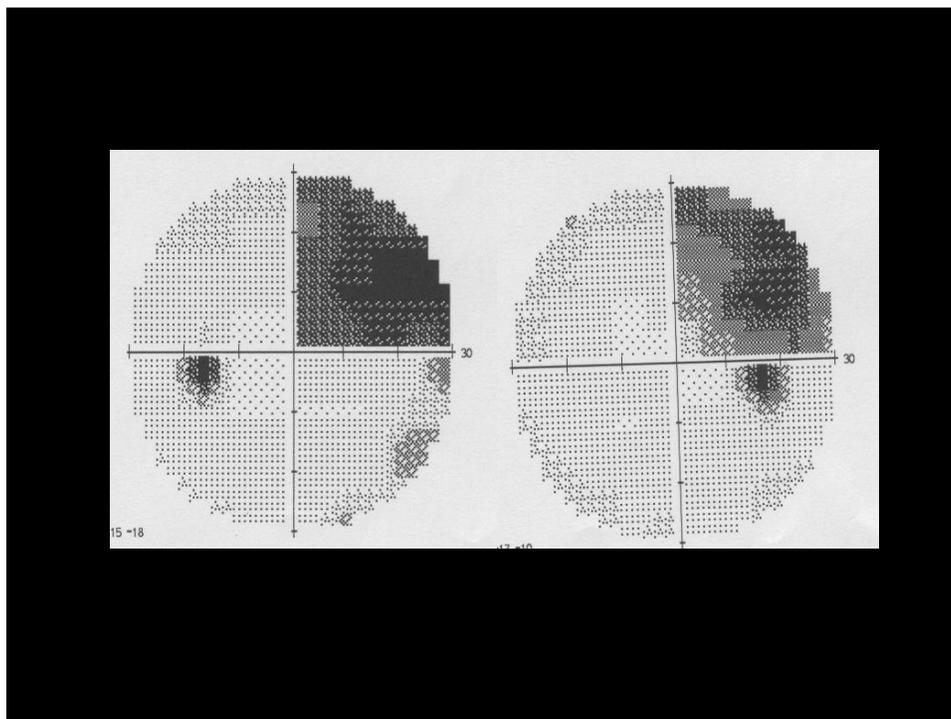


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## 56 y/o Hispanic Male

- C/o difficulty seeing objects up & to his right
- BVA:
  - 20/20 OD
  - 20/20 OS

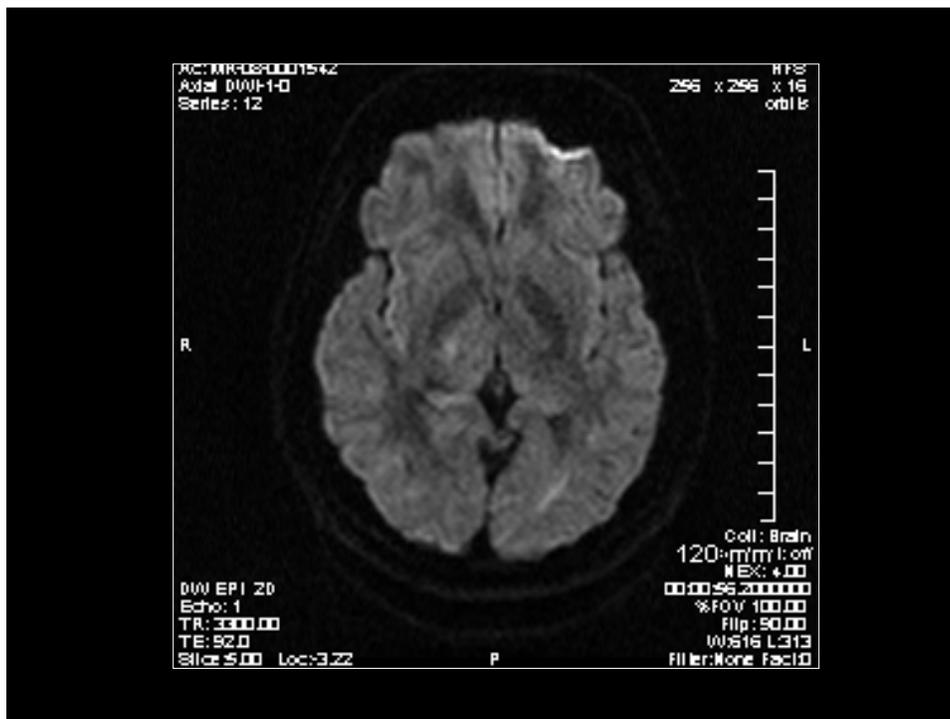
174



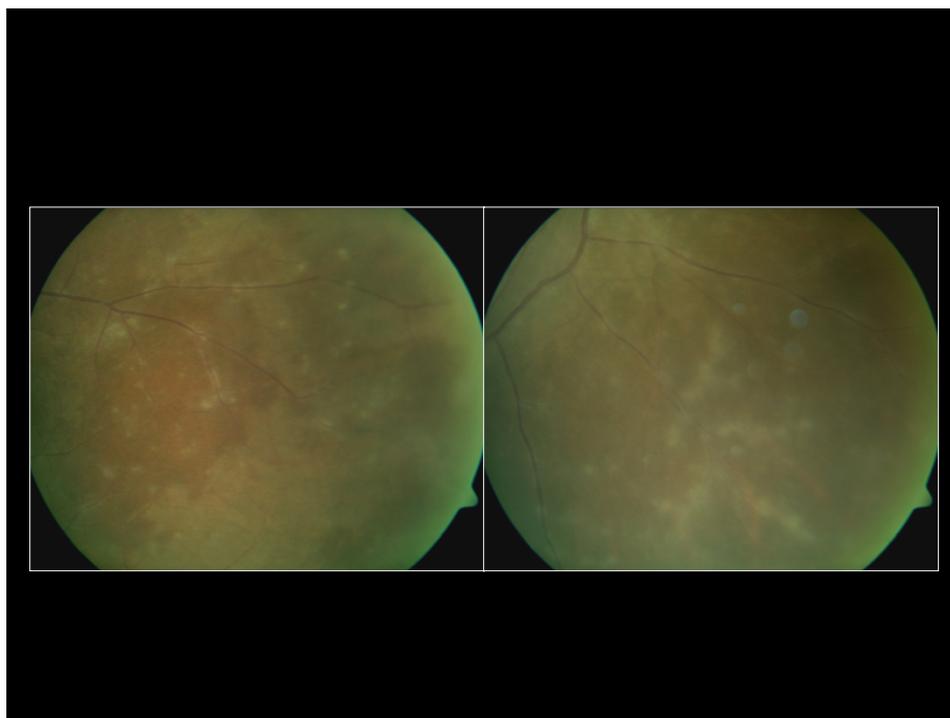
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## **The Rest of the Story...**

- Treated for gonorrhea 30 yrs. ago
- **Serology:**
  - + FTA-Abs
- **CSF:**
  - Protein (86.7 mg/100 ml)
  - IgG (14.7 mg/100 ml)
  - IgM (2.0 mg/100 ml)
  - + VDRL

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## **CNS Syphilitic Vasculitis**

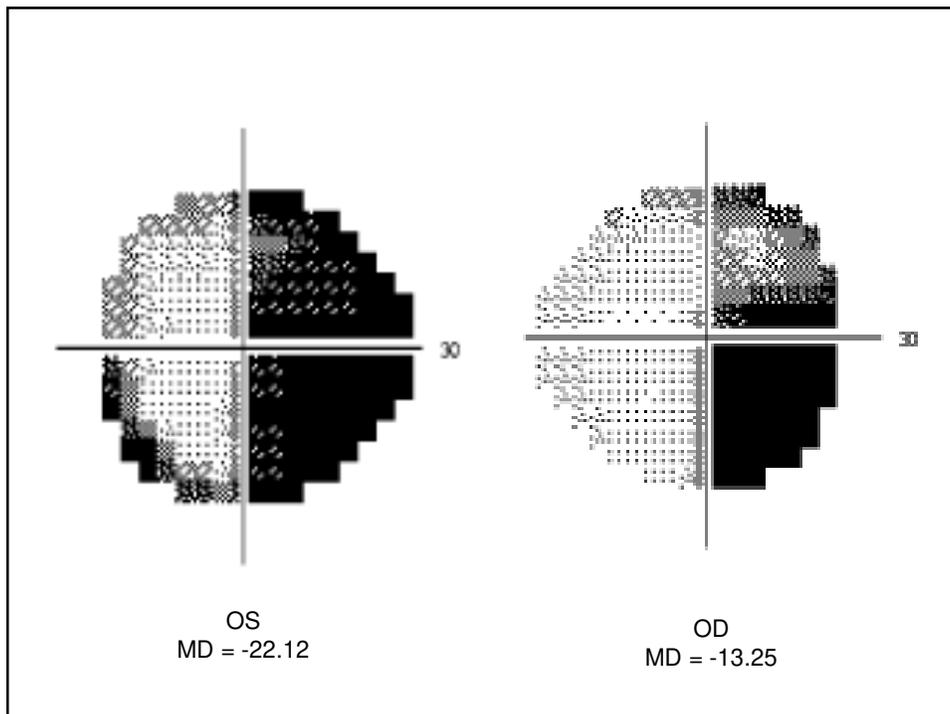
- Positive FTA-Abs / CSF VDRL
- Elevated protein and pleocytosis
- Commonly along distribution of **middle cerebral artery** (less often with basilar artery distribution)

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## 46 y/o AA Male

- C/o difficulty seeing objects to his right (approx. 6 mos)
- Right side hemiparesis
- + HIV & syphilis
- BVA:
  - 20/20 OD
  - 20/20 OS

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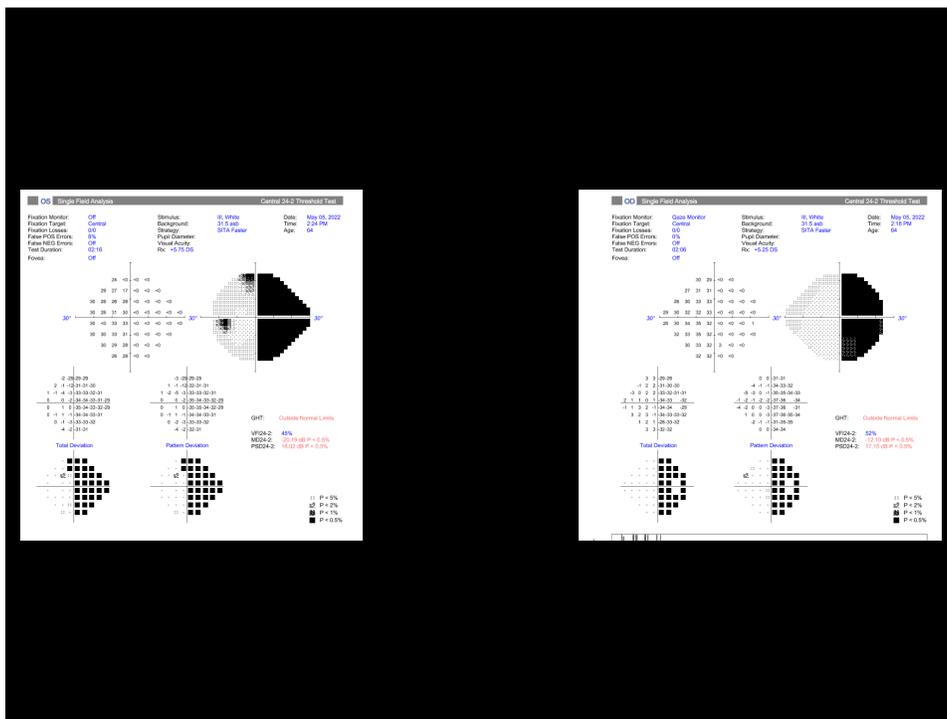


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## 72-y/o Man

- C/o loss of vision on right side
- BVA: 20/20 OU
- PMI: DM & HTN x 25-30 yrs.

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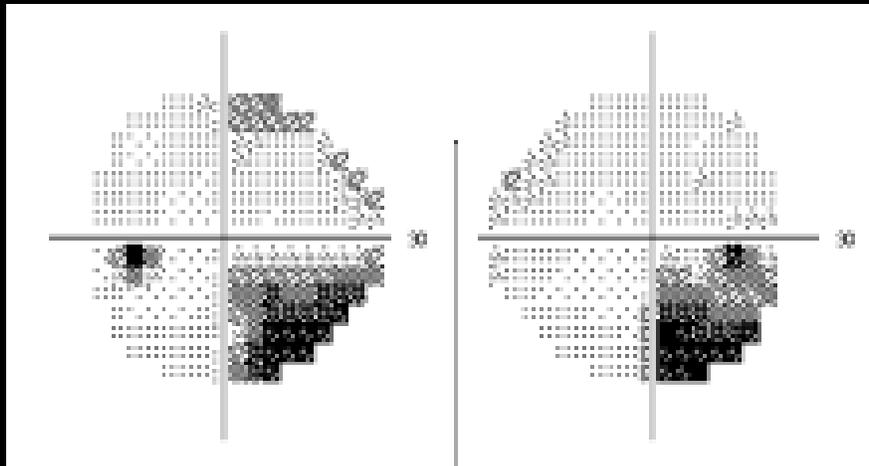


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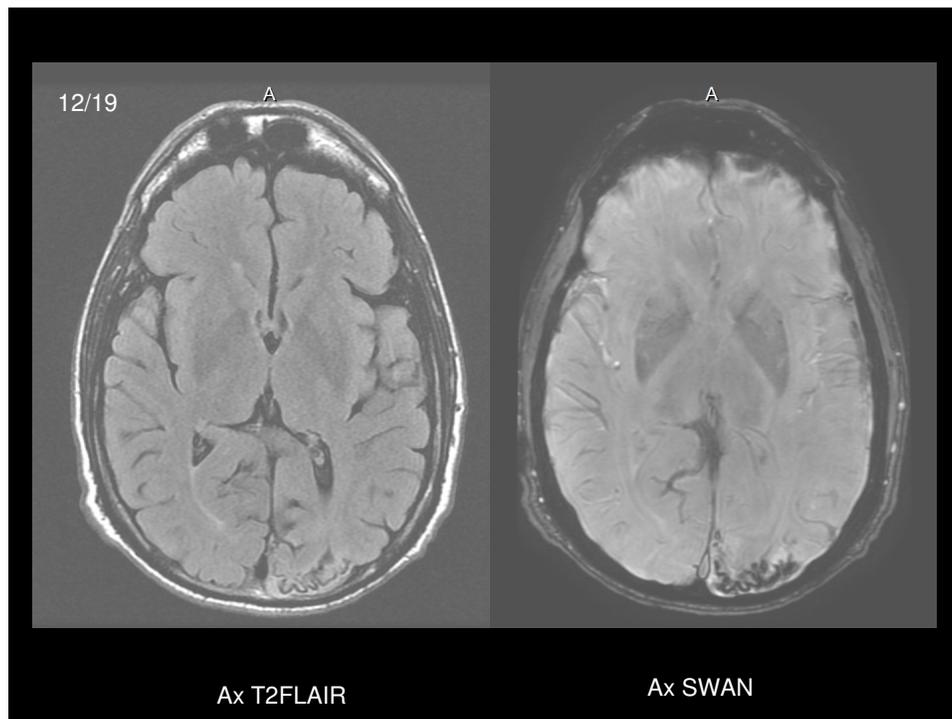
## 44 y/o AA Man

- C/o difficulty seeing objects down & to his right (“scintillating” quality)
- + seizures
- BVA:
  - 20/20 OD
  - 20/20 OS

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## Occipital Lobe Arteriovenous Malformations

- Occipital epilepsy
  - Flashes of light
  - Homonymous field defects (dimming)
- Occipital apoplexy (acute hemorrhage)
  - Sudden onset headaches
  - Homonymous field loss
- *Confusion with migraine*

Troost & Newton Arch Ophthalmol 1975

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## Occipital arteriovenous malformations:

### Visual disturbances and presentation

M.J. Kupersmith, MD; M.E. Vargas, MD; A. Yashar, MD; M. Madrid, RN, PhD; K. Nelson, MD;  
A. Seton, MD; and A. Berenstein, MD

- Retrospective analysis of 68 patients with occipital lobe AVMs
  - Homonymous visual field loss: 57%
  - Headache: 57%
  - Seizures: 29%

Kupersmith MJ, et al. *Neurology* 1996

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## Treatment Options

- 30% natural risk of hemorrhage (highest risk with thalamic, basal ganglia & brainstem AVMs)
  - Resection
  - Radiosurgery
  - Embolization
  - Observation

Yang Y, et al. *Neurosurgery* 2014

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## Key Points

- Neuroanatomical planes of the body
- Correlative neuro-anatomy and neuroradiology & other imaging for visual pathway lesions
  - Chiasm
  - Retro-chiasm

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## Thank you!



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