Humphrey Visual Field Essentials for Technicians

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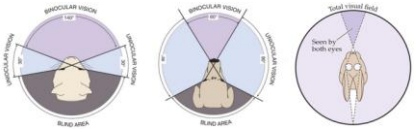
FINANCIAL DISCLOSURES

- Shana Barrett Zeitlin, O.D. has no financial interests to disclose.
- All images were taken from the Internet. I do not own any of the images.

OUTLINE

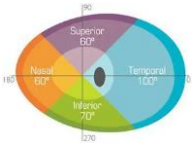
UNDERSTANDING THE VISUAL FIELD

- The entire area that can be seen while the eyes are fixed on a central point
- The extent of space in which objects are visible at any given moment of steady fixation without the need to move the eyes or head



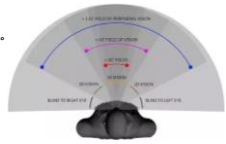
MONOCULAR VISUAL FIELD

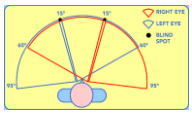
- What one eye sees independently
- Central field
  - Inner 30°
  - Central fixation, high acuity
- Peripheral field
  - 60° superior, up to 70° inferior, up to 100° temporal, 60° nasal
  - Motion, changes in lighting, situational awareness
- Physiologic blind spot
  - Optic nerve (RNF exits through scleral canal)
  - 12° to 17° from fixation; 1.5° below the horizontal meridian

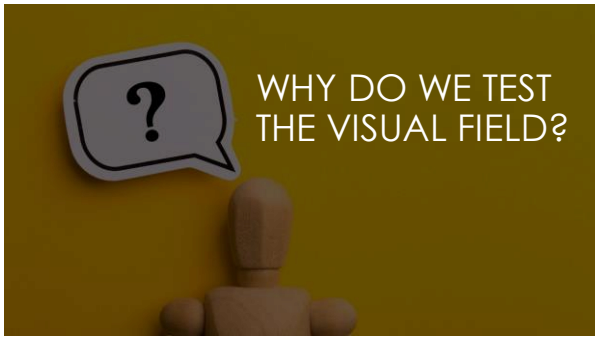


BINOCULAR VISUAL FIELD

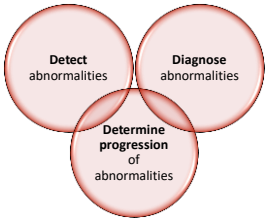
- Overlapping region of the visual fields of both eyes
- Depth perception
  - Distance between objects
- Stereoscopic vision
  - Objects in 3D
- Binocular overlap: 120°



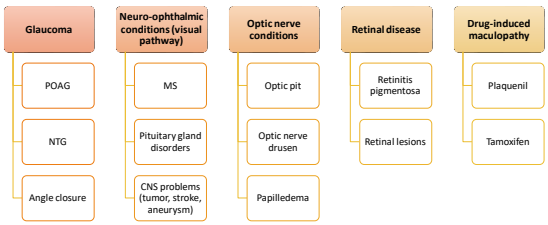




GOALS OF VISUAL FIELD TESTING



VISUAL FIELD: TESTING INDICATIONS



VISUAL FIELD: TESTING INDICATIONS

- **Drivers' visual function**
- **Disability certification**
- **Legal blindness**
- **Ptosis/dermatochalasis**
- **Thyroid eye disease (Graves)**
- **Unexplained vision loss**

TESTING THE VISUAL FIELD

- Confrontation visual field
- Frequency doubling technology
- Amsler grid
- Perimetry (automated, manual)
- Tangent screen

PERIMETRY: MEASURING THE VISUAL FIELD

Static

Presents stimuli at specific locations in the visual field

Area is fixed, but varies in intensity

Measure the sensitivity of specific points within the visual field

Detect subtle visual field defects

Monitor changes over time

Humphrey (HFA), Octopus, virtual field units

Kinetic

Stimulus moves from non-seeing area to a seeing area

Map the boundaries of the visual field

Establish the extent of field loss

Goldmann, CVF, Tangent screen

AUTOMATED PERIMETRY

Static perimetry for measuring visual function outside of the fovea

Determines dimmest and smallest stimulus at predetermined test point locations

Patient responds to stimuli using a button or clicker

Visual threshold: ability to detect a stimulus under defined testing conditions

Precise quantification of visual sensitivity

Compare with normal thresholds

Advantages

Standardized

Reproducible

Numerical data analyzed statistically

Data stored and retrieved for comparison (progression analysis)

Disadvantages

Challenging and frustrating for patients

Learning curve

Retest variability

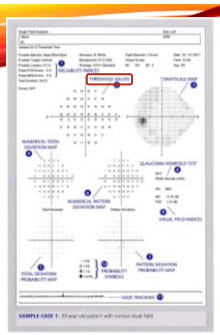
RETINAL SENSITIVITY

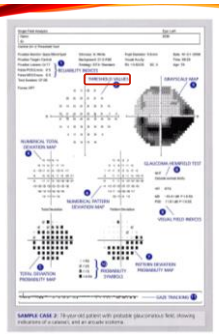
Highest at the fovea

Reduces towards the periphery

LIGHT STIMULUS USED FOR TESTING

- Sensitivity to light is measured in decibels (dB: 0-50 in standard automated perimetry)
- Decibel is the logarithmic representation of the intensity of the light stimulus
  - It has a direct correlation to the sensitivity of the retina
- We use 0-50 in standard automated perimetry
  - Zero decibels (dB) represent the brightest light stimulus
  - 50 dB represents the dimmest stimulus-- higher than normal sensitivity would be needed to see it!
- So a **zero-decibel stimulus** will be visible to a point on the retina with the **lowest sensitivity** (and vice versa)
  - Lower dB value = "worse" VF
  - Higher dB value = "better" VF





WHAT IS **THRESHOLD**?

- "The intensity of the light stimulus, which, when presented at a particular location, is detected by the corresponding retinal point at least 50% of the time"
- Humphrey testing uses the Staircase method: "4-2-1"

STAIRCASE METHOD: "4-2-1"

Method 1: Increasing intensity

Initial stimulus is not seen

The intensity of the stimulus is **increased** by 4 dB steps until seen

Once visible, the intensity is reduced by 2 dB steps until again not visible

Then the intensity is increased again by 1 dB until again it is visualized again. This final dB reading is the threshold.

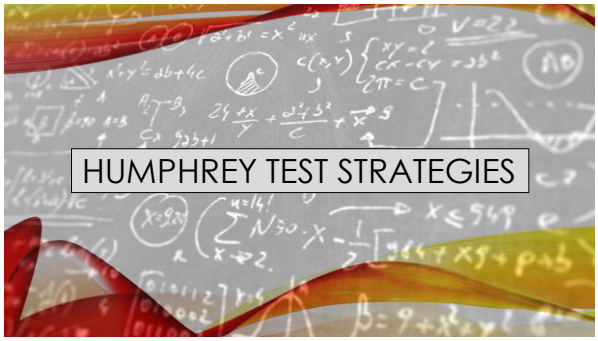
Method 2: Decreasing intensity

Initial stimulus is seen

the intensity of the stimulus is **decreased** by 4dB until not visible

Then the intensity is increased by 2 dB till it is seen

Then the intensity is decreased again by 1 dB until it is not seen. This final dB reading is the threshold.

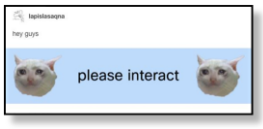


WHY USE TESTING ALGORITHMS?

- Improve attention
- Minimize fatigue
- No one wants to take a long test!
- Some examples:
  - Full threshold
  - SITA standard
  - SITA FAST
  - SITA FASTER
  - FAST-PAC

PHYSIOLOGIC BLIND SPOT

- Blind spot mapping makes a test more reliable
- Please get out your phones!

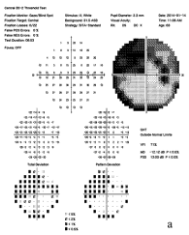


HUMPHREY VISUAL FIELD

- Limited number of points on the retina are checked for their retinal sensitivity
- Location and the pattern of the points tested
  - Decided by the different programs available on the machine
- Threshold tests
  - Central: 30-2, 24-2, 10-2, macular program
    - 24-2C on HFA-3 adds some central-10 points
  - Peripheral: peripheral 60-4, nasal step (additional 12 location up to 50° nasal), temporal crescent
  - Specialty: neuro 20°, neuro 30°
  - Estermann: binocular >130°

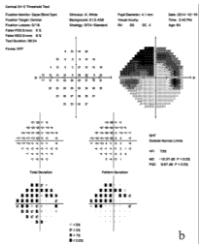
30-2

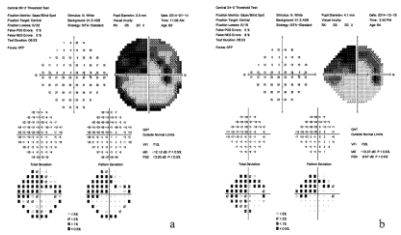
- Tests the central 30° field of the retina, with fovea as fixation
- Gives a round printout with 30° radius around the fovea
- "-2": the points are not located exactly on the vertical or horizontal midline
  - Points are equidistant from midlines
  - Better to document the visual fields obeying the horizontal (glaucoma) and vertical (visual pathway lesions)
  - In HFA-1, points are located at the midline in the 30-1 test
- 76 total points tested
- Each point is 6° from the other in the 30-2 test
  - Leaves a bare, unevaluated area between the points
  - Circle with a radius of 3 degrees between any four points



24-2

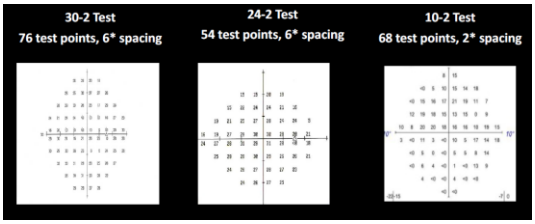
- Subset of 30-2 where the outermost points are eliminated, retaining two nasal points
  - Specifically to look for nasal steps in glaucoma
  - Points eliminated are not considered when diagnosing glaucoma
- Tests 54 total points
  - Better program for the elderly (↓ time)
  - ↓ false negatives due to patient's fatigue, as the outer points are the last ones to be tested
  - The distance between any two points remains 6°
- Because the distance between two points is 6°, paracentral scotomas can be missed on 24-2 & 30-2
  - Any defect **close to fixation** on these programs should be **retested** with the 10-2 program
  - 10-2 → higher resolution → highlights these defects





10-2

- Tests the central 10° radius of the retina (20° total)
- 68 closely placed points with 2° between any two points
  - A circle with a radius of only 1° remains unevaluated between any four points
- No glaucoma hemifield analysis (GHA) or visual field index (VFI) calculated
- Why is there no blind spot mapped on this test?
  - Optic nerve position?



STIMULUS TYPE AND SIZE

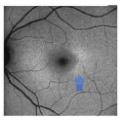
- White on white background
  - SAP (standard achromatic perimetry)
  - Most commonly used stimulus type
- Blue on yellow background
  - SWAP (short-wavelength automated perimetry)
  - SWAP test stimulus may target a subset of retinal ganglion cells affected earlier in glaucoma
- Stimulus size
  - Most common size: type III (4 mm^2)

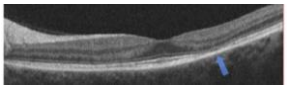
Target	Size (mm^2)	Degrees
0	1/16	6 min of arc
I	1/4	0.1 degrees
II	1	0.2 degrees
III	4	0.43 degrees
IV	16	0.8 degrees
V	64	1.7 degrees

RED STIMULUS?

Do what your doc says! But....

- Older literature: red target is more sensitive, so it should be used
- Test results usually look worse when a red stimulus is used
  - Harder for people to see the stimulus, so it is actually more sensitive
  - More "noise", loss of specificity
- Newer research: either is acceptable, as long as examiners:
  - Understand test variability
  - Have a low threshold for early signs of abnormality
  - Add objective tests (OCT, mfERG, FAF)
- Subtle white field losses can be confirmed with red fields, if necessary

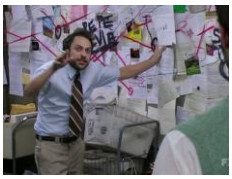




HOW TO ENSURE GOOD RESULTS

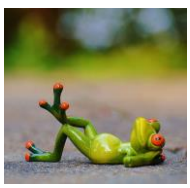
THE SINGLE MOST IMPORTANT THING YOU CAN DO:

EXPLAIN the test clearly!



ENSURE GOOD RESULTS

- Take the test yourself
- Patient physical comfort (height, seating, position)
- Patient mental comfort
  - Calm patient gives more reliable results
  - Able to pause test
  - Know what's coming
- Provide encouragement and reassurance
- Monitor gaze while testing



ROOM ILLUMINATION

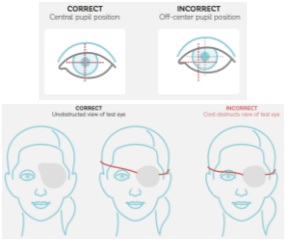
Room light during boot-up must be the same as the room light during testing!

- Machine measures ambient light
- Machine adjusts the background illumination relative to the ambient light
- The stimulus intensity is a factor relative to the background illumination

DARK ADAPTATION

- Bright waiting room to testing room?
- Dim dilation waiting room to testing room?
- Do OCT first in the same dim testing room?

PATIENT EYE POSITIONING



PATIENT INSTRUCTIONS: DURING THE TEST

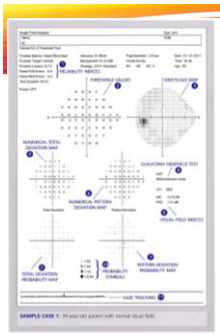
- "Look into the center of this bowl-shaped instrument called a perimeter."
- "The eye not being tested is covered with a patch."
- "The testing eye will have your lens prescription placed in front of it to make sure you are seeing as well as possible."
- "You may blink normally during the test. You may also pause the test if you feel you need to take a break for a moment."
- "Keep looking at a center target throughout the test."
- "Small, dim lights will begin to appear in different places throughout the bowl. Press the button whenever you see a light."
- "The machine tracks which lights you do and do not see."

PATIENT INSTRUCTIONS: ABOUT THE TEST

- "Because you are looking straight ahead during the test, your doctor can tell which lights you see outside of your central area of vision."
- "Since glaucoma affects peripheral vision, this test helps show if there is vision loss outside of your central visual field."
- "The lights do not move across the screen, but blink at each location with differing amounts of brightness. This allows the machine to find the dimmest light you can see at each location in your peripheral vision."
- "You may be concerned because you can't see every light. This is how the test is supposed to work."
- "The machine will show some lights that are too dim for you to see. This is done deliberately to find what is called the *visual threshold* of each location, meaning the brightness that you have trouble seeing half the time."

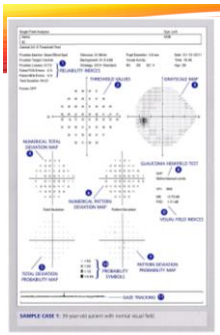
DURING THE TEST

- Mitigate patient anxiety
- Actively monitor the patient's test performance
  - Watch fixation monitor
  - Coaching– without distracting!
  - Point out possible repeat testing if unreliable
- Make sure the px sees the first stimuli
  - Algorithm may start with a very dim stimulus



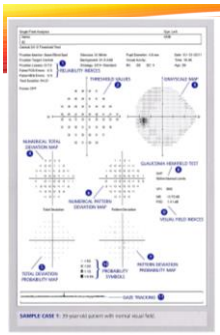
ANALYZING A HUMPHREY VF

1) Reliability indices
   - Fixation losses: Not reliable (>15-20%)*
     - Poor fixation = unreliable test result
   - False positive: trigger happy (>5-10%)*
     - Hit the button when there's no stimulus
     - Great video game players?
   - False negative: bored (>10-15%)*
     - Miss the lights they SHOULD see (based on past responses)
     - Not paying attention
2) Threshold values
   - Measured in dB
   - Higher number = better sensitivity
3) Grayscale: patient education



ANALYZING A HUMPHREY VF

4) Numerical total deviation map
   Deviation from age-matched "normal" @ each point
5) TD Probability
   Statistical significance of missed points
6) Numerical PSD
   Deviation measured in dB but removes distractors
7) PSD probability
   Statistical significance of missed points



ANALYZING A HUMPHREY VF

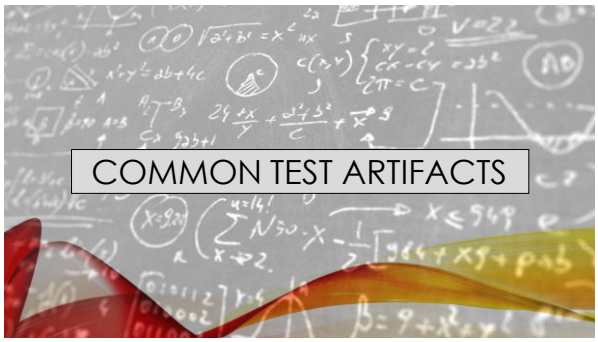
8) GHT: Glaucoma hemifield test
   Compares mirror image clusters of points above and below midline
   MD-24: weighted average of values from age-matched "normal" @ each point
9) VF Indices
   VFI: overall marker of field loss similar to the MD
   → Patients with values below 70% may begin to notice functional defects
   MD (Mean deviation): weighted average of TD values
   PSD (Pattern standard deviation): highlight localized defects by "removing" generalized visual field loss
   → Likely due to a cataract
10) Probability symbols
11) Gaze tracking

WHAT IF YOUR PATIENT ISN'T RESPONDING?

- Awake?
- Waiting for you to say something?
- Very advanced glaucoma?
  - Initial stimulus size may be too small to be seen
  - May need different test strategy!
    - Switch to 10-2 if only a central island of vision remains
    - More sensitive for their remaining field
  - May need different stimulus
    - Increase the size?
    - Caution with progression analysis!
- Increased testing time can indicate fatigue

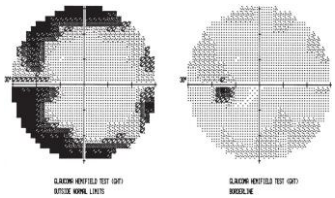
PREVENT SOME UNRELIABLE RESULTS

- Dermatochalasis
- Ptosis
- Patient comfort
  - Attention? Tired? Bored?
- Dry eyes
- Lens placement
- Gaze-tracking software
- Cataracts: a possible source of depression of the mean deviation
  - After cataract surgery, the mean deviation may decrease in magnitude
  - The pattern deviation may increase as more focal glaucoma defects are revealed



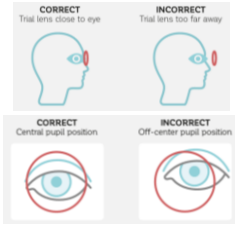
LENS RIM ARTIFACTS

- All of the outer points on the visual field have a steep drop-off to a dB value **zero or less than zero**
- All the points directly adjacent to it are normal!



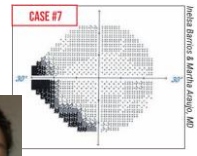
LENS RIM ARTIFACTS

- Caused by the rim of the lens that was placed in front of the patient's eye
  - Need trial lens to correct refractive error
  - Inappropriate head positioning can cause the lens rim to block peripheral stimuli
- Trial lens placement
  - **Ask** if the patient can clearly see the target through the lens
  - Contact lenses?



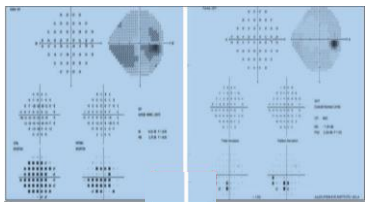
MASKING DEFECT

- Superior nasal step scotoma– not real!
- 2020: patients started wearing masks because of COVID-19
- Scotoma went away when the mask was taped down!
  - Related defect: worsening scotomas caused by **fogging**
- Tape down the nasal/superior mask



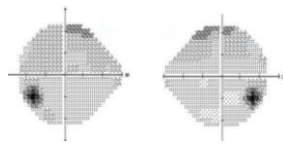
WRONG/MISSING TRIAL LENS

- Too much blur with uncorrected refractive error
- Unable to see stimuli clearly
- About 1dB of depression in VF for every 1D of blur

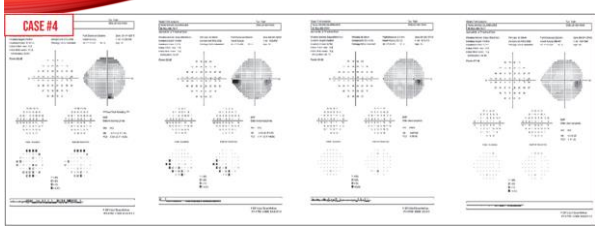


GREAT FIXATION…. ON THE WRONG TARGET

- In this visual field the blind spot is much lower than we'd expect it to be
- Patient fixated on the marks for foveal threshold testing (below the central fixation light)
  - Make sure to tell the patient to change fixation after foveal threshold testing!



LEARNING CURVE



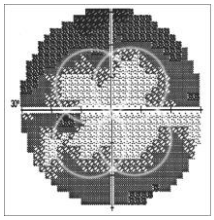
Peripheral defects → Inferior nasal step (glaucomatous?) → Nasal step disappeared → Normal VF

DERMATOCHALASIS

- Superior defect, prominent on the TD and PSD plots: Looks arcuate!
- Severe dermatochalasis obstructing periphery
- Can also be a rim defect!
  - Chin can slip off-center in the chinrest
  - Head becomes tilted a bit
  - Patient is then looking upwards with a chin-down position
  - So, superior test point lights could be blocked by the trial lens
- Clue: values are <0dB

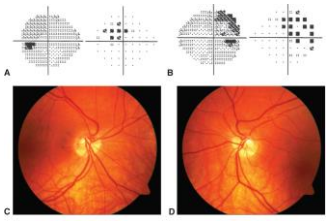
CLOVERLEAF

- Central points in each quadrant are much lighter than the surrounding points
  - Indicates an unreliable test
- The computer has four primary points that it tests first, near the center of each quadrant
- Correlate with optic nerve appearance
  - Nerve will be much healthier than VF makes it seem
- Poor attention, fatigue
- Malingering
- High false negatives



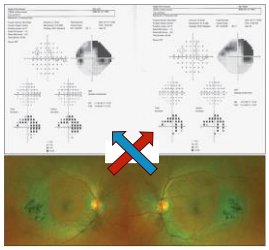
HIGH MYOPE: TILTED DISC

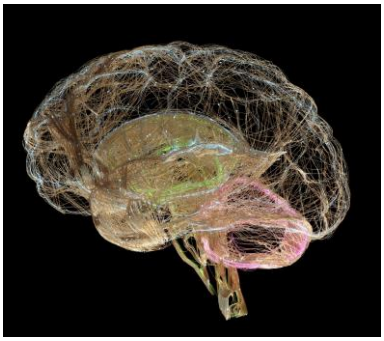
- "Refraction scotoma"
- Tilt causes a part of the retina to be farther away from the point of best focus
- The trial lens brings light into focus anterior to the retina that tilts posteriorly with the nerve
- Stimulus test lights in those locations are blurred on the retina
- Typically this area will be superior, because most nerves are tilted inferiorly



RETINAL ABNORMALITIES

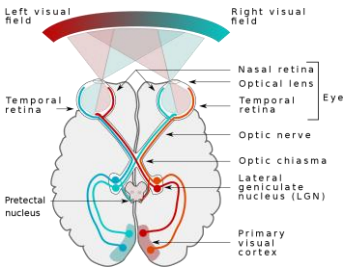
- Impressive superior arcuate and inferior nasal step defects
- Grayscale map: the defects don't appear to be typically glaucomatous
- For such an advanced arcuate scotoma, one would expect more paracentral involvement, and there's a lot of temporal depression.
- Physical exam:
  - Nerves look normal!
  - Retina has a pigment epithelium abnormality in a circular shape
  - Mimics RNFL defects on VF



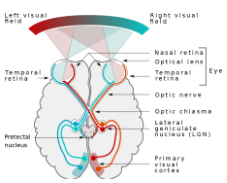


VISUAL PATHWAY AND ANATOMY

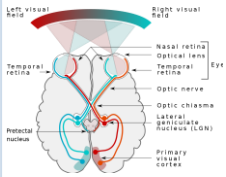
VISUAL PATHWAY



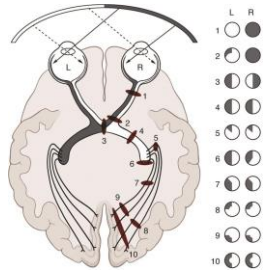
Retina	Optic Nerve	Optic Chiasm
• Innermost layer of the eye • Contains specialized photoreceptors (rods and cones) • Photoreceptors capture light and convert it into electrical signals • Rods: low-light vision • Cones: color vision and high-acuity vision	• Bundle of nerve fibers that carries the electrical signals generated by rods and cones • Transmits these signals from the eye to the brain, specifically to the lateral geniculate nucleus (LGN) of the thalamus	• Junction point where some of the nerve fibers from each eye cross over to the opposite side of the brain



Optic Tract	Lateral Geniculate Nucleus (LGN)	Visual Cortex (Primary Visual Cortex - V1)
• After crossing at the optic chiasm, the nerve fibers continue as the optic tract • Carries visual information to various brain structures, including the LGN and superior colliculus	• Relay station in the thalamus that receives visual input from the optic tract • Processes and relays this information to the primary visual cortex (V1) in the occipital lobe of the brain • Role in visual perception, including contrast and motion detection	• Located in occipital lobe • Primary processing center for visual information • Interprets the signals received from the LGN • Responsible for basic visual functions, such as edge detection, orientation, and simple object recognition • The information is then further processed by higher-order visual areas for complex perception, including color and motion perception, facial recognition, and object identification



LESIONS AND CORRESPONDING DEFECTS



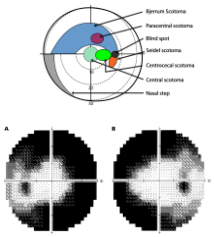
COMMON FIELD DEFECTS

Scotoma

- Area of reduced or lost vision within the visual field
- Can be small or large
- Central scotoma: macular conditions
- Glaucoma, optic nerve damage, retinal diseases

Constriction of Visual Field

- Reduction in the overall size of the visual field
- "Tunnel vision"
- Retinitis pigmentosa, advanced glaucoma



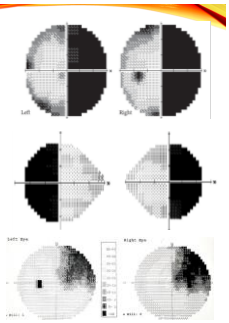
COMMON FIELD DEFECTS

Hemianopia

- Half of the visual field is lost
- Homonymous: loss of half of the visual field on the same side in both eyes
- Heteronymous: loss of half of the visual field on different sides in each eye
- Bitemporal: loss in the outer (temporal) half of both visual fields
  - Chiasm (pituitary tumors)
- Stroke, brain injuries, tumors/lesions

Quadrantanopia

- Loss of one-quarter of the visual field
- Can occur in different quadrants of the visual field
- Optic tract, optic radiations, visual cortex



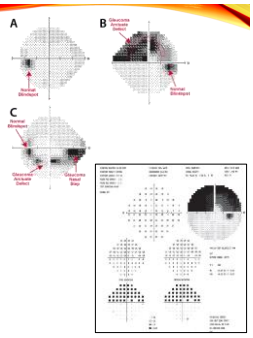
COMMON FIELD DEFECTS

Arcuate Defect

- Curved or arc-shaped area of reduced sensitivity within the visual field
- Common in glaucoma

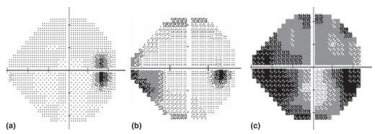
Altitudinal Defect

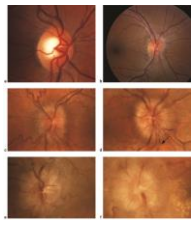
- Loss of vision in the upper or lower half of the visual field
- Ischemic optic neuropathy, retinal detachment, advanced glaucoma

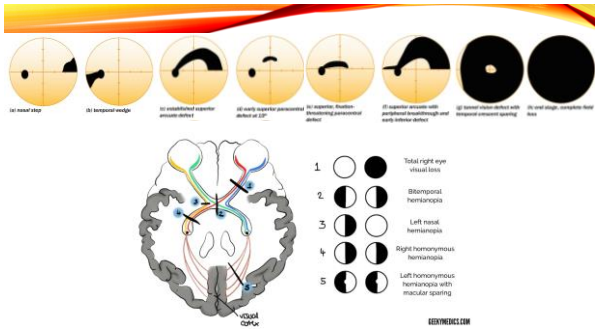


PROGRESSION OF PAPILLEDEMA

- Central acuity typically spared initially
- First defect is enlarged blind spot
- Progressive constriction, worse nasally
- Severe constriction with generalized depression







Pattern of Visual Field Loss	Classic Location of Defect
Generalized decrease in sensitivity	Media opacity (cornea, lens, or vitreous), decreased attention
Constriction of the visual field	Retina, optic nerve, small pupils
Ring scotoma	Retina degeneration
Central scotoma	Macula or optic nerve
Cecocentral scotoma	Papillomacular nerve bundle or nearby retina in region between the macula and optic nerve head
Arcuate scotoma	Arcuate retina ganglion cell nerve fiber bundles or retinal vasculature
Temporal wedge	Nasal retina radial fibers entering the optic nerve
Blind spot enlargement	Optic nerve
Multiple scattered defects	Retina
Hemifields respecting the horizontal meridian	Retina ganglion cell nerve fiber bundles or less commonly retinal vasculature
Hemifields respecting the vertical meridian	Optic chiasm or posterior visual pathways
Bitemporal	Optic chiasm
Homonymous	Optic chiasm or optic radiations
Horizontal tongue	Lateral geniculate body
Congruous bilateral defects	Nearer to the posterior visual cortex
Incongruous bilateral defects	Nearer to the optic chiasm
"Pie in the sky"	Temporal lobe
"Pie on the floor"	Parietal lobe
"Punched out" defects	Occipital lobe

Table 1. Optic Neuropathies Commonly Detected with Visual Field Testing

Idiopathic intracranial hypertension	Early: enlarged blind spot Late: generalized constriction[1,4] (can improve with treatment)
Optic neuritis	- Diffuse visual field loss (in almost half of cases) - Other: altitudinal defect, central or cecocentral scotomas, arcuate or double arcuate defects and hemianopic defects[5,7]
Non-arteritic anterior ischemic optic neuropathy	- Altitudinal defects that respect the horizontal midline are most common -Other: central scotomas, arcuate defects and quadranopsias[1,4]
Posterior ischemic optic neuropathy	- Central field defect[1,3]
Hereditary optic neuropathies **- Leber's hereditary optic neuropathy** **- Dominant optic atrophy**	- Cecocentral and central visual field loss[3]
Optic nerve head drusen	- May mimic a glaucomatous pattern
Thyroid ophthalmopathy	- Large variability - May partially or fully resolve after treatment[6]
Medication-induced toxic optic neuropathy	- Ethambutol (for tuberculosis treatment) toxicity may cause central scotomas and, less commonly, peripheral constriction and altitudinal defects[3] - Vigabatrin (an anti-epileptic drug), may cause field defects that begin as bilateral nasal defects and later progress to concentric field defects while the central field remains intact[3]