INTRAOCULAR PRESSURE

ALLIED OPHTHALMIC TRAINING PROGRAM

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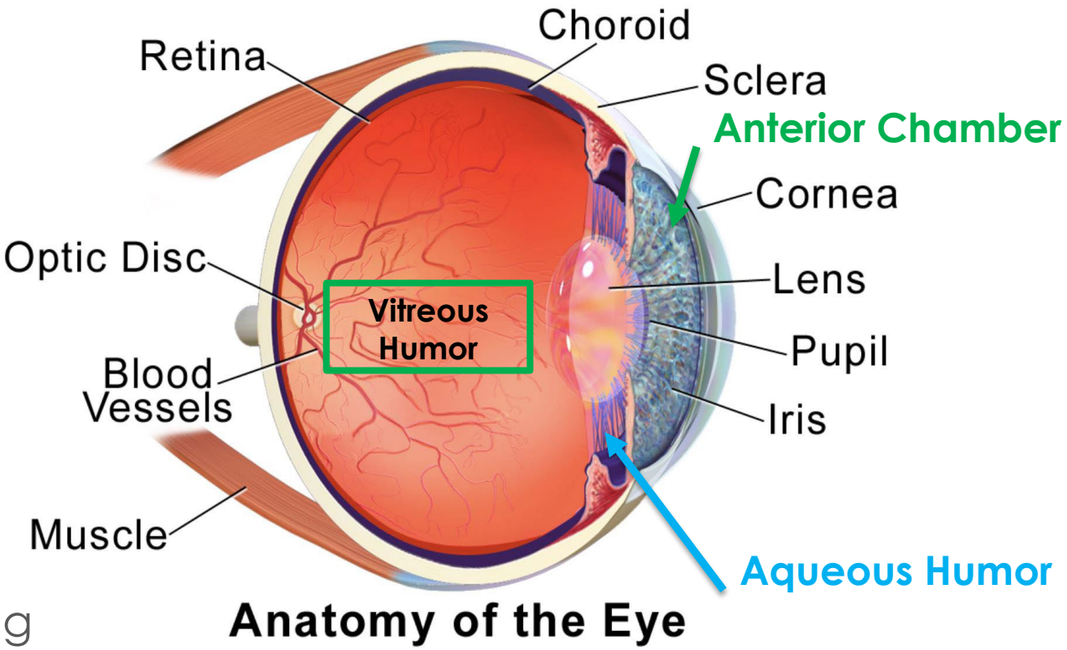
OUTLINE

1. What is Intraocular Pressure (IOP)?
2. Flow of Aqueous Humor
3. Diseases Involving Abnormal IOP
4. How Can We Measure IOP?
5. Common Ways To Measure IOP
6. Goldmann Applanation Tonometry
7. iCare Tonometry
8. Tonopen
9. Recording IOP
10. Factors that affect IOP

WHAT IS INTRAOCULAR PRESSURE (IOP)?

- One of the "5 Vital Signs of Ophthalmology"
  - Visual Acuity
  - Pupils
  - **Intraocular Pressure**
  - Extraocular Motility
  - Confrontational Visual Fields
- IOP is the **fluid pressure** inside the eye, which helps maintain the shape of the eye and its structures
- There are two "fluids" in the eye
  - **Vitreous Humor:** clear jelly that fills most of the eye behind the lens (posterior chamber), static
  - **Aqueous Humor:** fluid that fills the space in front of the lens (anterior chamber), and is constantly being produced and drained
    - **Contributes the most to IOP**
- **Normal IOP is 10-21 mmHg**



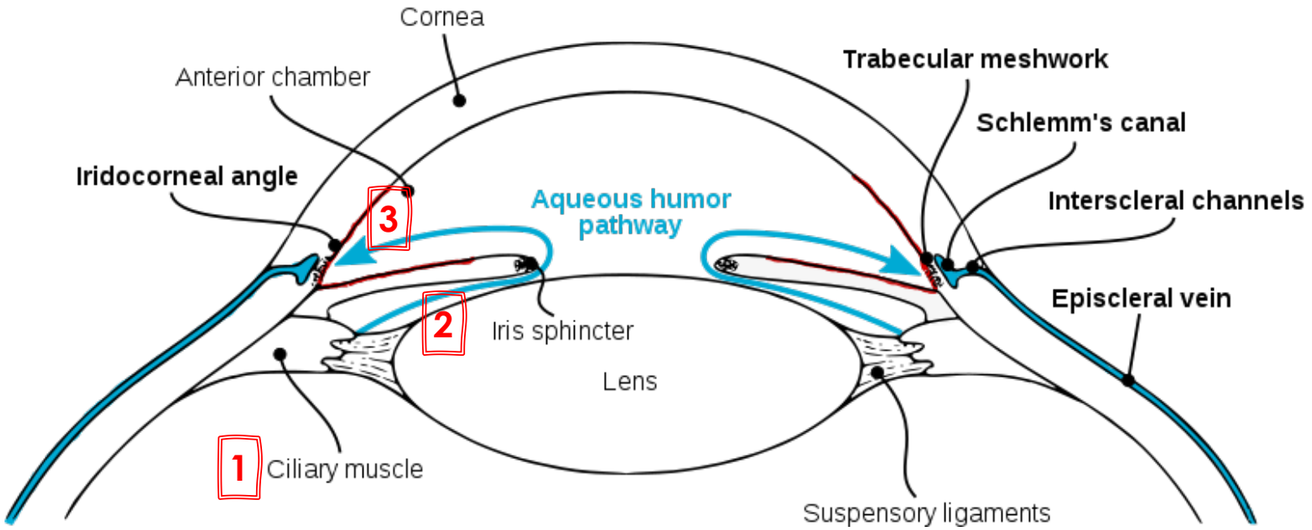
Anatomy of the Eye

[Source: https://commons.wikimedia.org/wiki/File:Blausen_0388_EyeAnatomy_01.png]

FLOW OF AQUEOUS HUMOR

1. Aqueous humor is produced by the **ciliary body/ciliary muscle**
2. It then flows forward between the lens and the back of the iris, through the pupil into the **anterior chamber**
3. Then into the corners between the cornea and the front of the iris, where it's drained through **trabecular meshwork** into Schlemm's canal into the venous system underneath the scleral surface

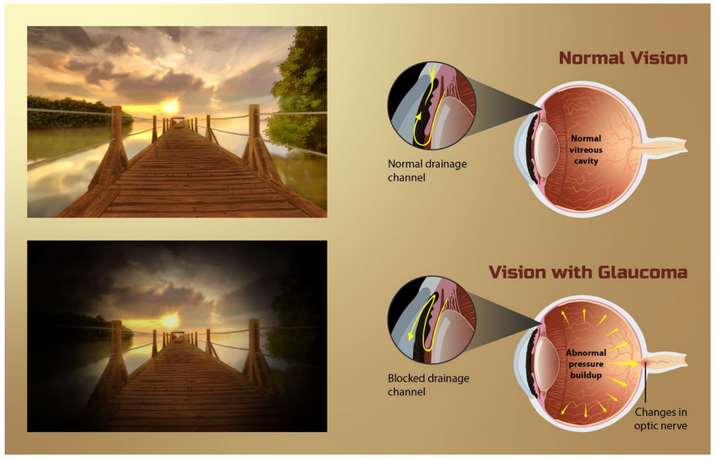
- Aqueous humor is constantly being produced and drained; the balance is what we measure with IOP
- **Too much or too little production or drainage** can affect the balance and lead to **an abnormally high or low IOP**

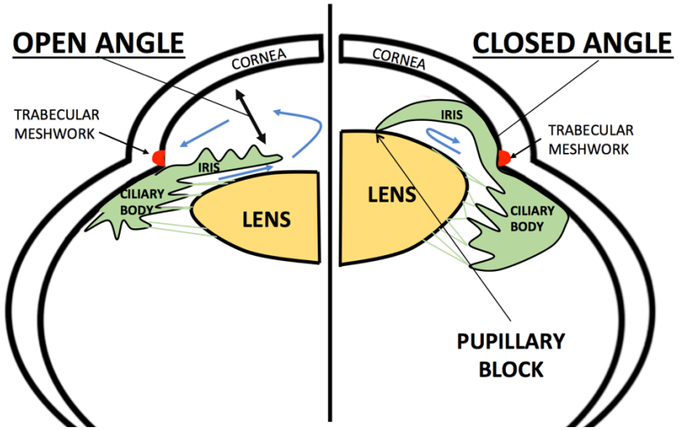


[Source: modified from https://commons.wikimedia.org/wiki/File:Aqueous_humor_pathway.svg]

DISEASES INVOLVING ABNORMAL IOP

- **Primary Open Angle Glaucoma (High IOP)**
  - Disease that damages the optic nerve and causes vision loss
  - IOP related optic nerve damage is implicated in its pathogenesis
- **Acute Angle Closure Glaucoma (High IOP)**
  - An ophthalmologic emergency where the IOP rises rapidly due to a sudden blockage of aqueous humor outflow
- **Ocular Hypertension (High IOP)**
  - IOP above normal range **without** optic nerve damage or visual field loss
  - 18% of these patients will develop glaucoma
- **Ocular Hypotension (Low IOP)**
  - IOP below normal range that can indicate reduced fluid production, increased fluid secretion, or fluid leakage, which can occur in trauma or surgery



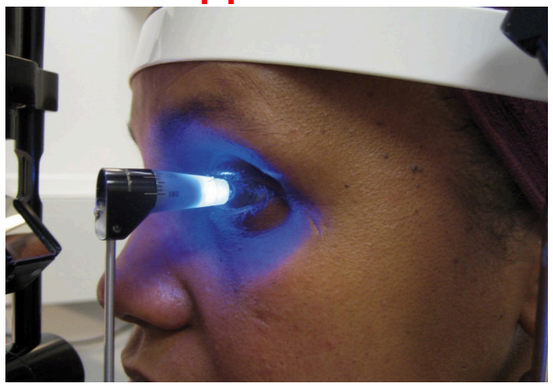


[Source: https://commons.wikimedia.org/wiki/File:Depiction_of_vision_for_a_Glaucoma_patient.png/, http://morancore.utah.edu/basic-ophthalmology-review/acute-angle-closure-glaucoma/#:~:text=Acute%20angle%2Dclosure%20glaucoma%20(AACG,block%20versus%20non%2Dpupillary%20block.]

COMMON WAYS TO MEASURE IOP

- Goldmann Applanation Tonometry
- iCare Tonometry
- Tonopen

Goldmann Applanation Tonometry



[Source: https://www.flickr.com/photos/communityeyehealth/5546698291/in/photostream/ (Applanation), Taken by Vincent Tang at the UC Davis Eye Center (Tonopen and iCare)]

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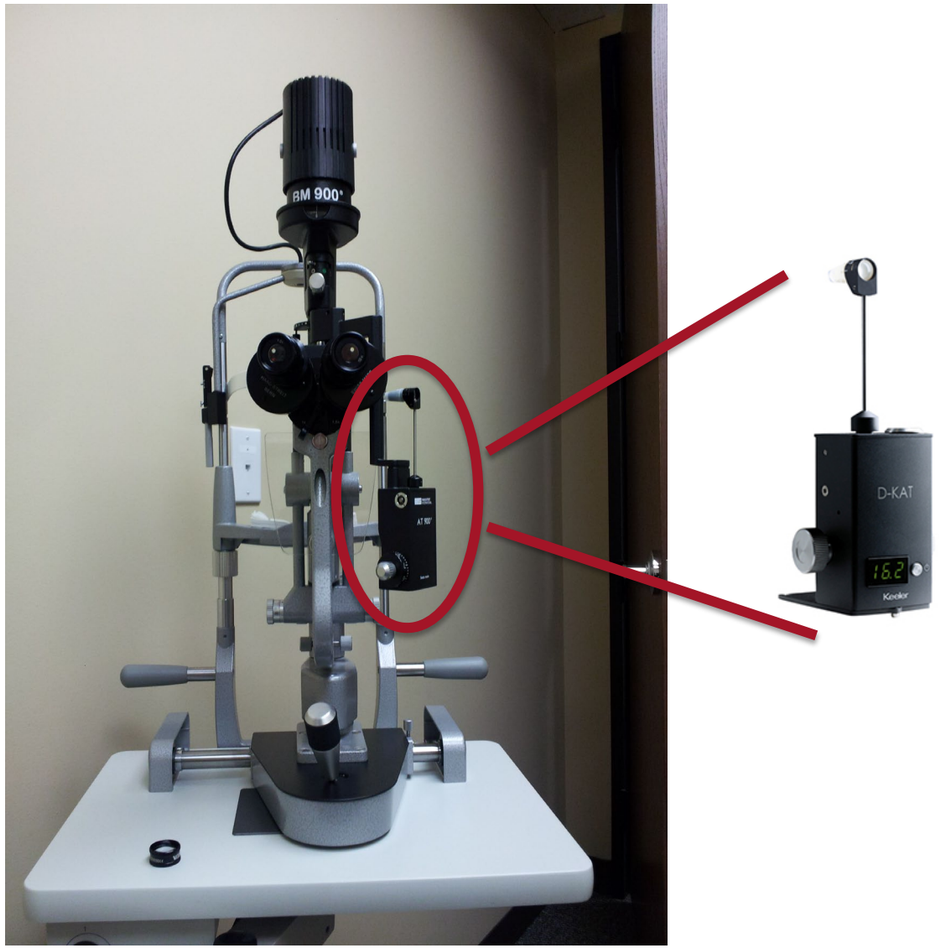
GOLDMANN APPLANATION TONOMETRY

- **Goldmann Applanation Tonometry** measures the force needed to flatten an area of the cornea to measure IOP based on the Imbert-Fick Principle



[Source: louisepaige.com, commons.wikimedia.orgwikiFileRetina_Group_slit_lamp_(doctor_side)]

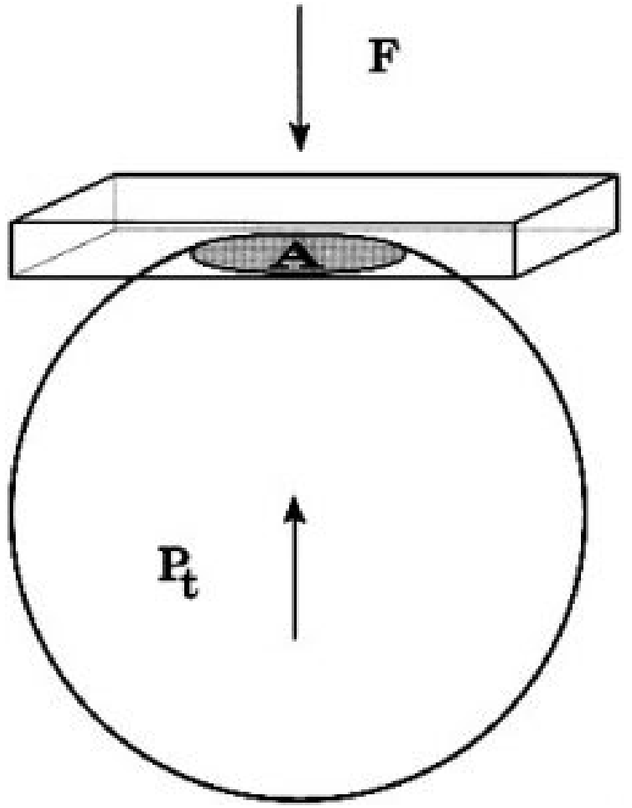
WHAT IS THE IMBERT-FICK PRINCIPLE?

- **Imbert-Fick Principle**
  - **Pressure** in a thin-walled sphere = **Force** required to flatten a specified area of the sphere divided by that **Area**

$$P = \frac{F}{A}$$

where **P** = **Pressure**, **F** = **Force**, **A** = **Area**

- Imagine how hard your thumb must press on a basketball to make a dent when it is deflated vs inflated
- Goldmann Applanation Tonometry measures IOP based on this principle



[Source: http://morancore.utah.edu/basic-ophthalmology-review/intraocular-pressure/]

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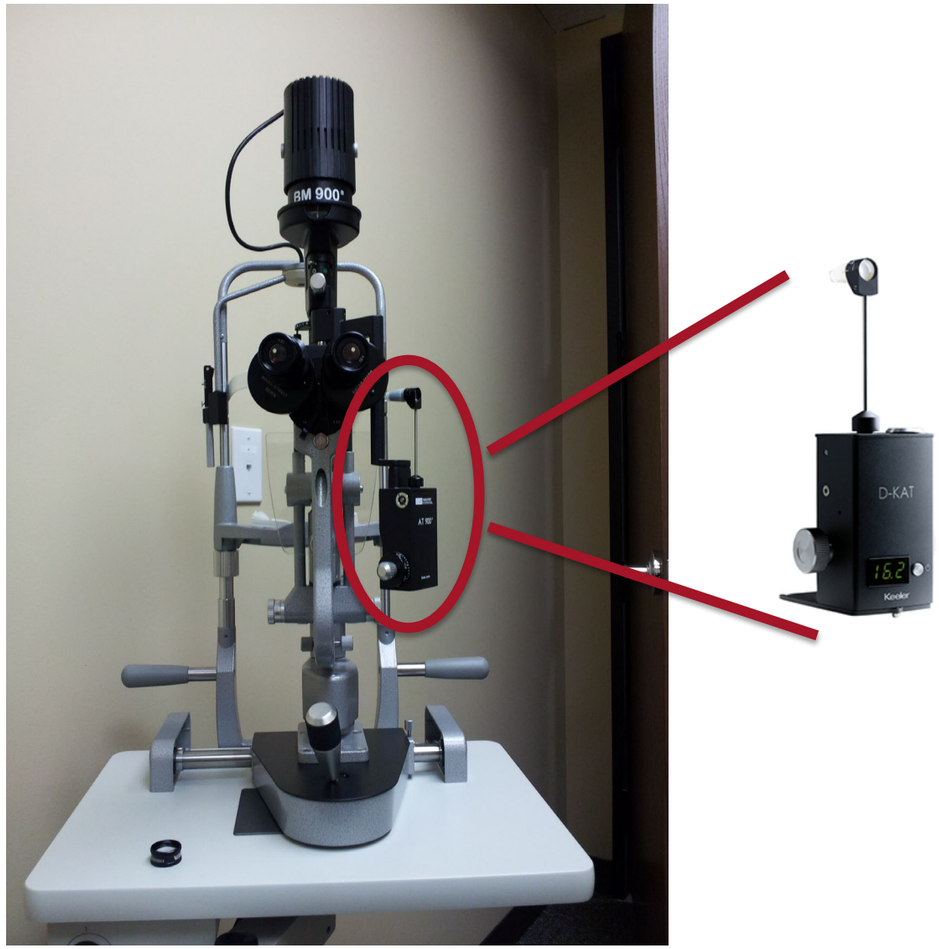
GOLDMANN APPLANATION TONOMETRY

- **Contraindications**
  - Infections
  - Open globe injuries
  - Corneal Injuries
- **Advantages**
  - **Most accurate (Gold Standard)**
  - Reproducible
- **Disadvantages**
  - Requires training
  - Not portable
  - Requires anesthetic
  - Poor technique can injure cornea
  - Unable to use it for patients who cannot sit upright (infants, bed-bound patients, etc.)



[Source: louisepaige.com, commons.wikimedia.orgwikiFileRetina_Group_slit_lamp_(doctor_side)]

GOLDMANN APPLANATION TONOMETRY

Preparation:

- **Sanitize Prism**
  - Wipe the tonometer tip clean
  - Soak in 10% bleach for 5 minutes
  - Rinse with water, and let dry
  - Remember to wash your hands!
- **Equipment Preparation**
  - Mount prism to device holder and rotate it so that the internal prism is horizontal/at 0° (when the "0" line on the prism is lined up with the white line on the holder)
  - Set light beam to maximum intensity, thickness, and height
  - Switch to blue filter
  - Set the illumination tower at an oblique angle of approximately 40° (to your left for measuring the patient's right eye, to your right for measuring the patient's left eye)
  - Turn applanation dial to the "1" mark (=10 mmHg)

Prism in Holder positioned at the "0" line

Applanation Dial @ "1" Mark (=10mmHg)

[Source: Taken by Vincent Tang at the UC Davis Eye Center]

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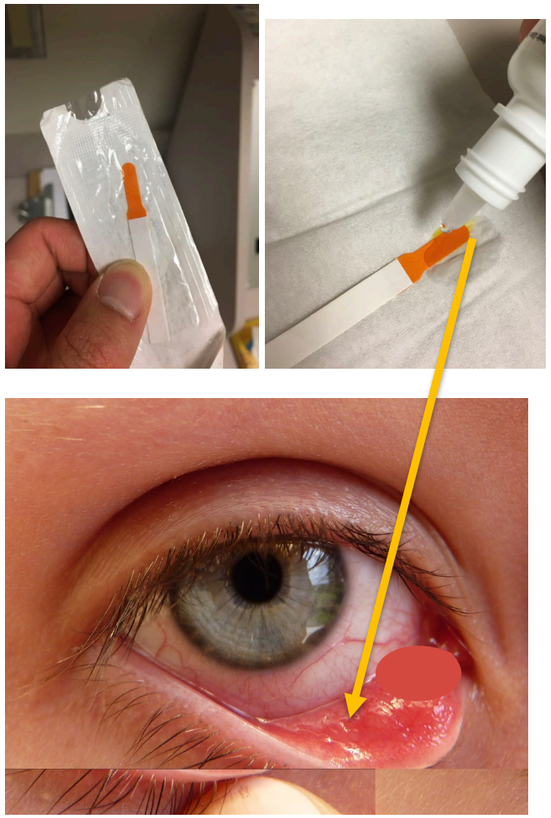
GOLDMANN APPLANATION TONOMETRY

- **Instilling Dye**
  - Instill either **Fluorescein/Proparacaine (Fluoracaine) Drops** into the patient's eyes OR use a **Fluorescein Strip**
  - To use the **Fluorescein Strip**
    1. Add a drop of proparacaine to the colored end of the strip
    2. First pull down on the lower lid and ask the patient to look up
    3. Gently touch the wetted fluorescein strip to either the **inferior bulbar conjunctiva** (well beneath the cornea) *or* to the **inferior palpebral conjunctiva** (inner lower lid)
    4. Have the patient blink to distribute the dye

Fluoracaine Drops

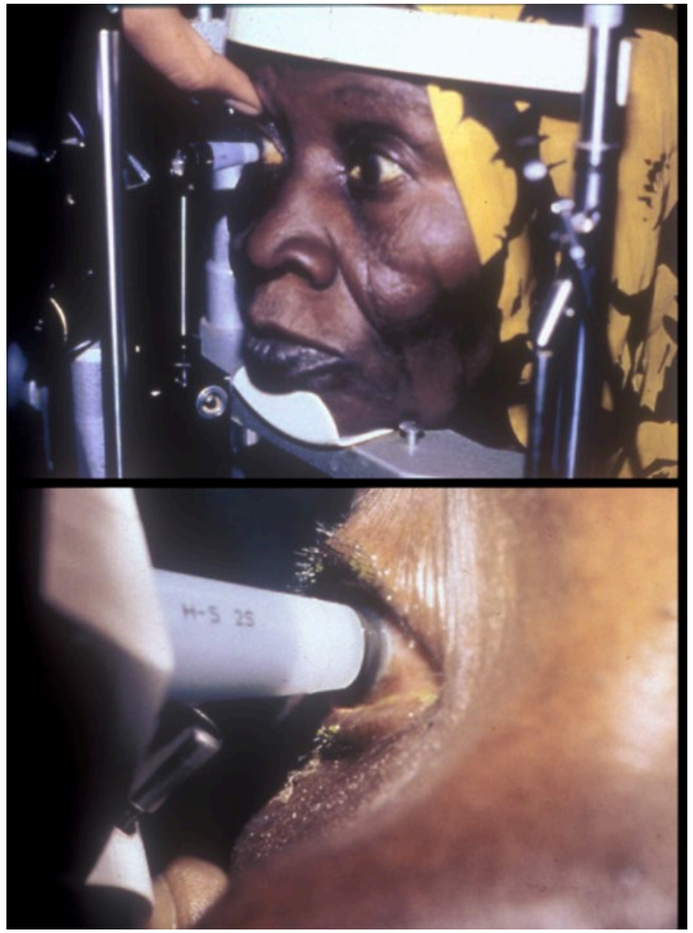
Fluorescein Strip



[Source:https://commons.wikimedia.org/wiki/File:Fluorescin_in_dropper.jpg/ (Fluoracaine Drops), https://commons.wikimedia.org/wiki/File:Hordeolum.JPG (Eyelid), Taken by Vincent Tang at the UC Davis Eye Center (Strip+Proparacaine Drop)]

GOLDMANN APPLANATION TONOMETRY

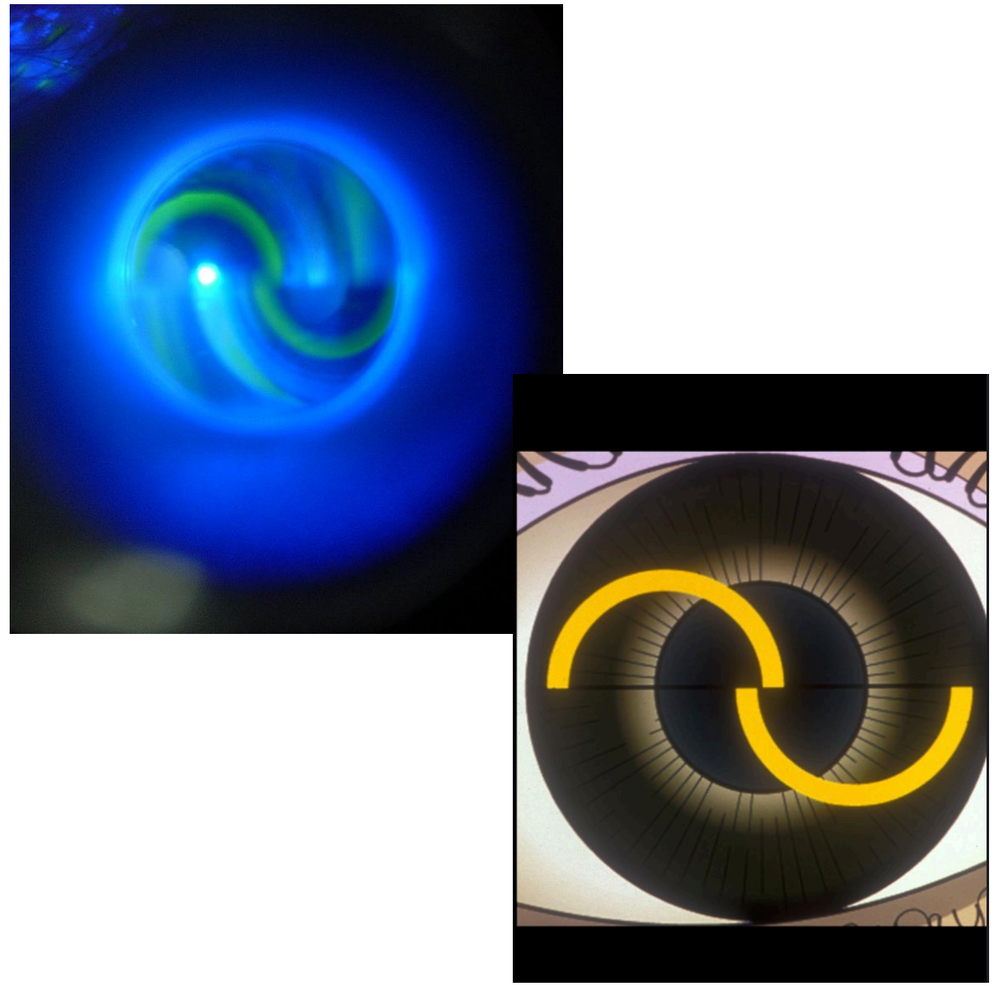
- **Measurement**
  - Tell the the patient to look **straight ahead** across the room or at your opposite ear with both eyes open
  - Gently hold the lids open with your fingers if necessary. **Make sure not to put pressure on the globe itself.**
  - **Look directly at the patient and the prism** (outside the slit lamp oculars) while using the slit lamp joystick to position the tonometer at the correct height to be in line with the center of the patient's cornea
  - Slowly move it forward towards the patient's cornea, stopping a few millimeters before contact
  - Look through the slit lamp oculars to **carefully** advance the prism the few remaining millimeters until it **just makes full contact** with the corneal surface



[Source: https://www.flickr.com/photos/communityeyehealth/5546698291/in/photostream/]

GOLDMANN APPLANATION TONOMETRY

- **Measurement *(continued)***
  - If the tonometer is in the correct position and there is the right amount of dye, you should **see two clear, bright yellow hemi-circles**
  - Rotate the applanation dial to increase the pressure on the globe until the **internal edges of both semicircles just touch**
  - Look at corresponding reading on the applanation dial and **multiply this by 10** to get the IOP (e.g. 1.5 x 10 = 15 mmHg)
  - Inaccurate alignment of the hemi-circles or too much or too little dye can lead to incorrect IOP readings
- **Finishing**
  - Take probe off the cornea as soon as possible for patient comfort and to prevent injury
  - Blot excess dye from the patient's closed eyelid margins using a tissue
  - Remember to sanitize the probe



[Source: https://commons.wikimedia.org/wiki/File:Goldmann_mires.jpg, https://www.flickr.com/photos/communityeyehealth/5546698291/in/photostream]

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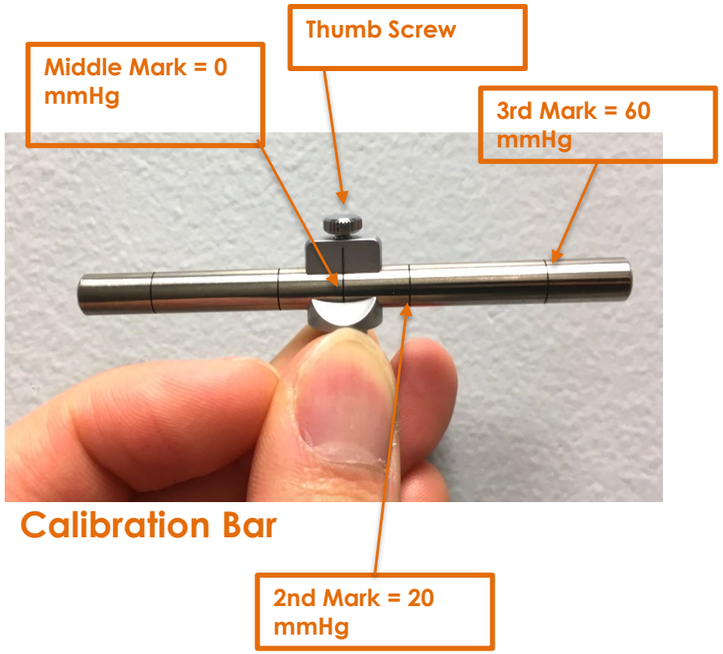
GOLDMANN APPLANATION CALIBRATION

Calibration

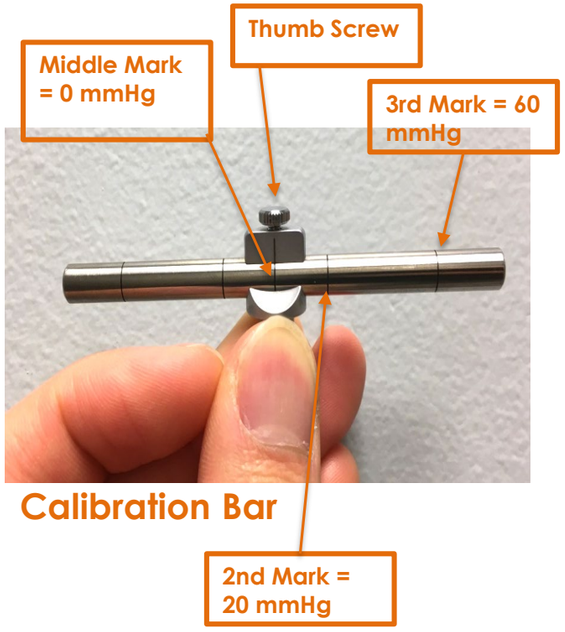
- Do this daily before use
- Place prism into holder
- Each mark on the weighted calibration rod represents a pressure reading
  - **Middle mark = 0 mmHg, 2nd mark = 20 mmHg, 3rd marking = 60 mmHg**
- Slide the reference block down the weighted rod until it reaches the 2nd mark (20 mmHg) and tighten the thumbscrew
- Take the calibration rod and insert the slotted part of the thumbscrew into the hole in the side of the tonometer
- Rotate the scale knob to the **"1" position**
- Rotate it slowly towards the **"2" position**
- If it is calibrated correctly, the probe should **move forward** when it reaches the "2" position
- Rotate the knob past "2" to **"3"** and slowly rotate back to "2"
- If it is calibrated correctly, the probe should move back when it reaches "2"
- You can repeat these steps for the 3rd mark (60 mmHg)



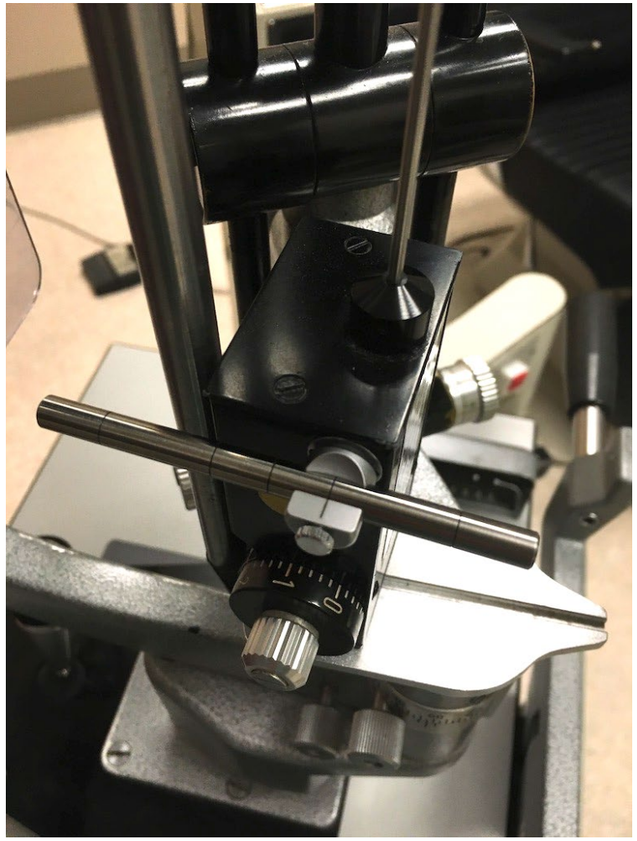
Calibration Bar

[Source: Taken by Vincent Tang at the UC Davis Eye Center]

GOLDMANN APPLANATION CALIBRATION



Middle Mark = 0 mmHg



2nd Mark = 20 mmHg

3rd Mark = 60 mmHg

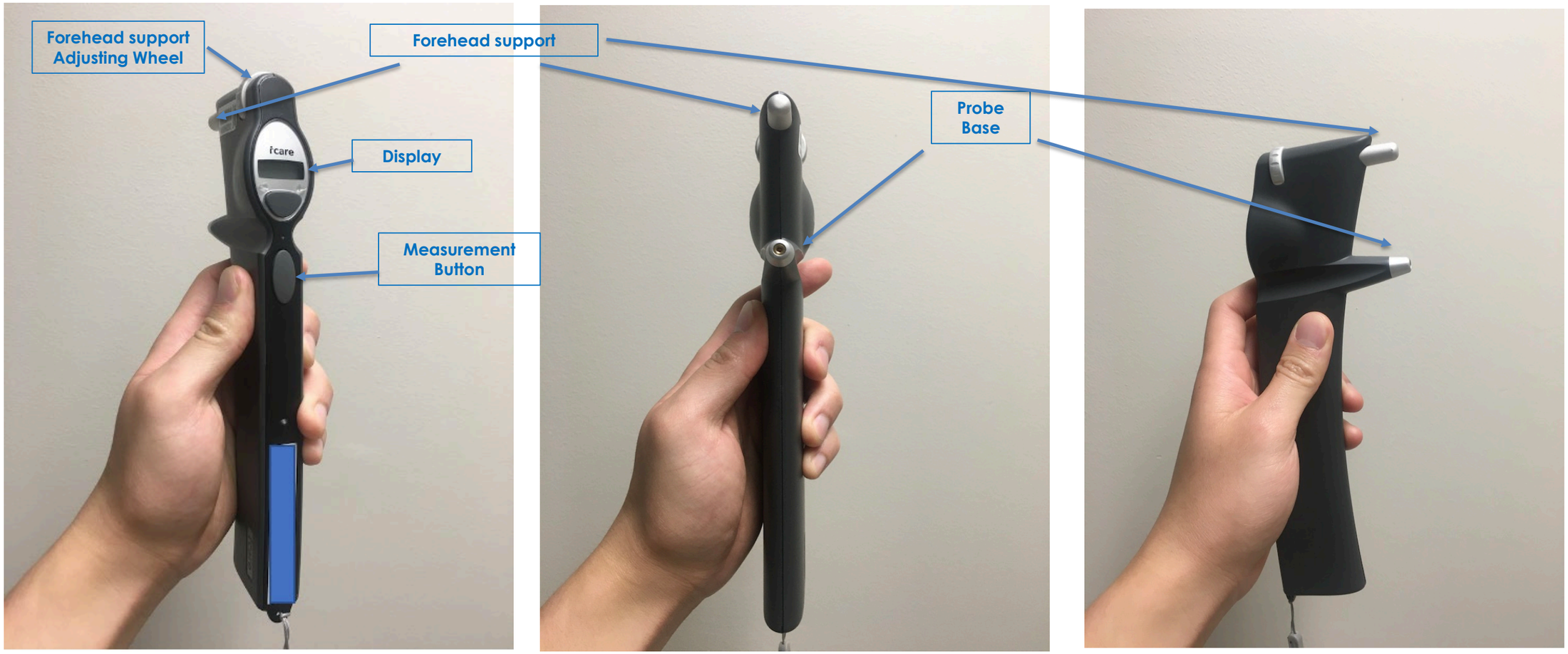
[Source: Taken by Vincent Tang at the UC Davis Eye Center]

ICARE TONOMETRY

- **iCare tonometry** measures IOP using a **magnetized bouncing probe**
- Based on the concept of **rebound tonometry**, the device calculates IOP based on the deceleration of the probe against the corneal surface
- **Advantages**
  - Portable and quick
  - No need for anesthetic
  - More comfortable for children
  - No need for slit lamp
  - Smaller contact area required so better for smaller palpebral fissures
  - Less likely to disturb corneal surface
  - No need for calibration
- **Disadvantages**
  - May overestimate IOP vs applanation per anecdotal physician experience
  - Cost of purchasing disposable probes

[Source: Moran Eye Center: http://morancore.utah.edu/basic-ophthalmology-review/intraocular-pressure/]

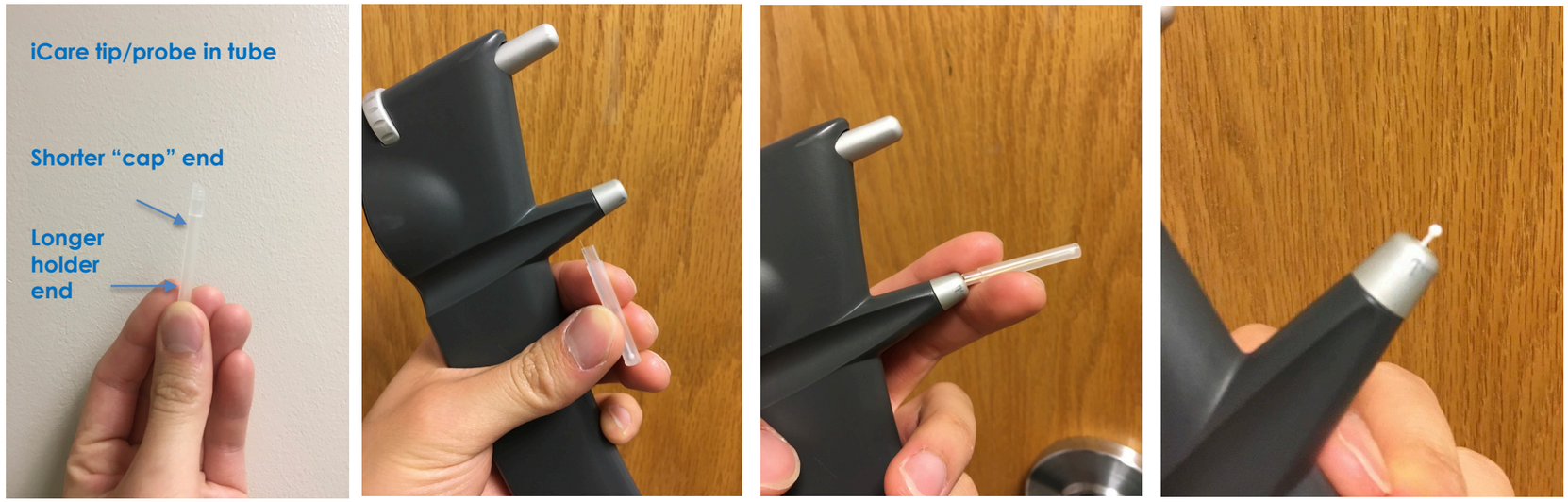
ICARE TONOMETER



[Source: Taken by Vincent Tang at the UC Davis Eye Center]

ICARE INSTRUCTIONS

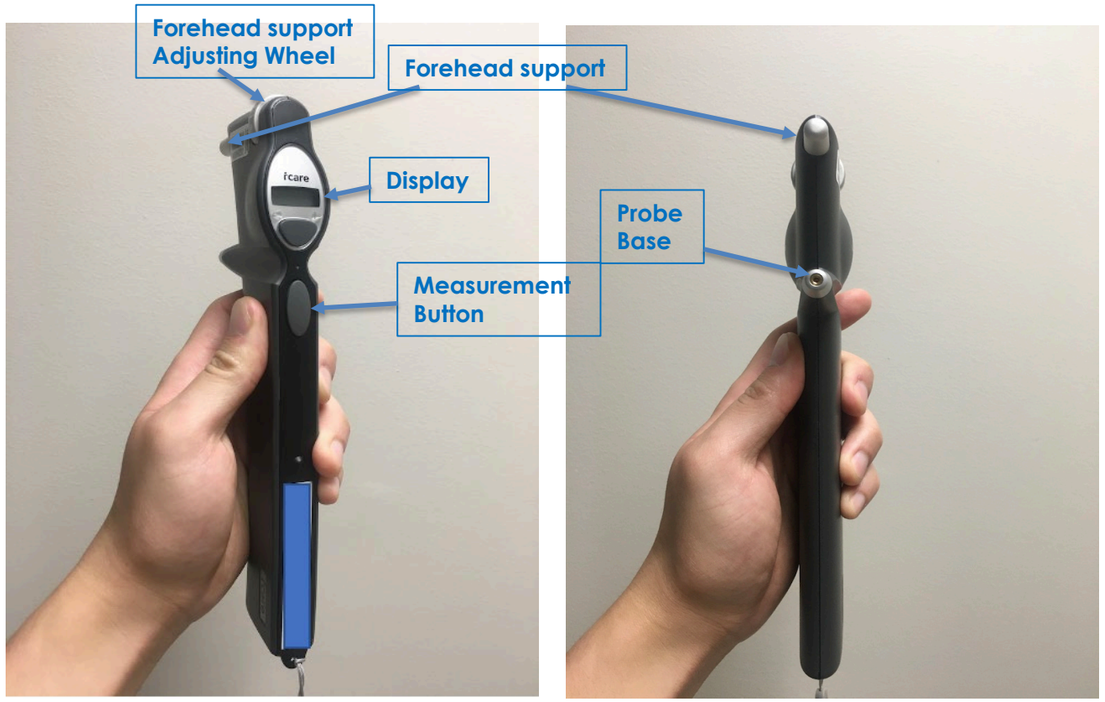
- **Loading Probe**
  - Press measurement button to turn it on/reset it
  - iCare tips/probes come enclosed in sterile tubes with a short "cap" end and a longer, holder end.
  - Remove the cap end of the tube to expose just the back end of the probe. Use the remaining holder end of the tube to insert the probe into the probe base without touching the tip directly. (See photos.)
- **Activating**
  - Press measurement button once and you will get a "00" display reading when the iCare is ready



[Source: Taken by Vincent Tang at the UC Davis Eye Center]

ICARE INSTRUCTIONS

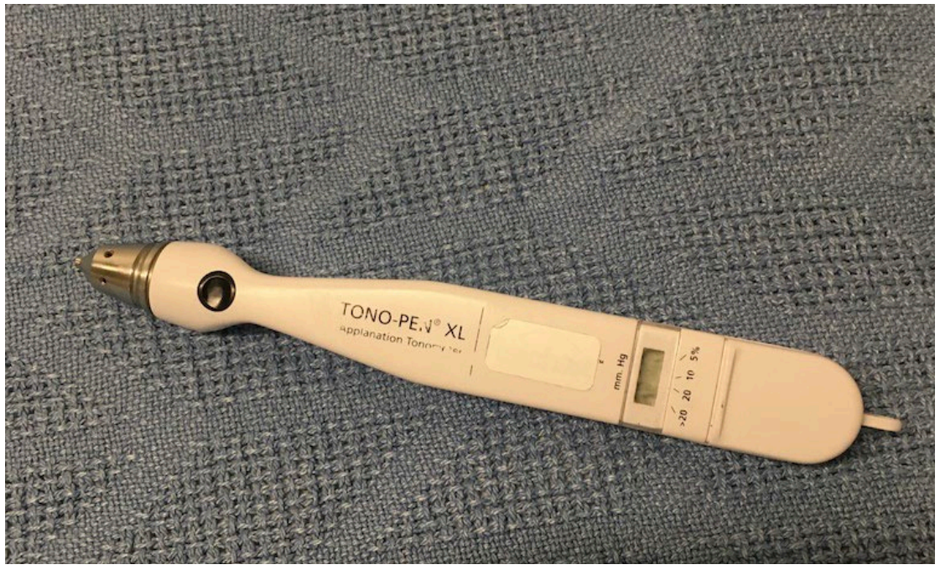
- **Measuring**
  - Have the patient look straight ahead
  - Bring the tip of the probe 4-8 mm away from the cornea
  - It should be perpendicular to the center of the cornea
  - Press the measurement button to perform the measurement
  - The tip of the probe should contact the center of the cornea and make a short beep
  - After **3-6 successful measurements** (depending on the model), there should be a long beep with the average IOP displayed
- Dispose of the probe after use



[Source: Taken by Vincent Tang at the UC Davis Eye Center]

TONOPEN

- The **Tonopen** is a portable, hand-held device that measures IOP using **indentation tonometry**, which calculates IOP by measuring the resistance of the cornea to indentation
- **Advantages**
  - Portable
  - Easy to use
  - Small contact area required
- **Disadvantages**
  - Can overestimate/underestimate IOP vs Applanation
  - Cost of disposable covers



[Source: Taken by Vincent Tang at UC Davis Eye Center]

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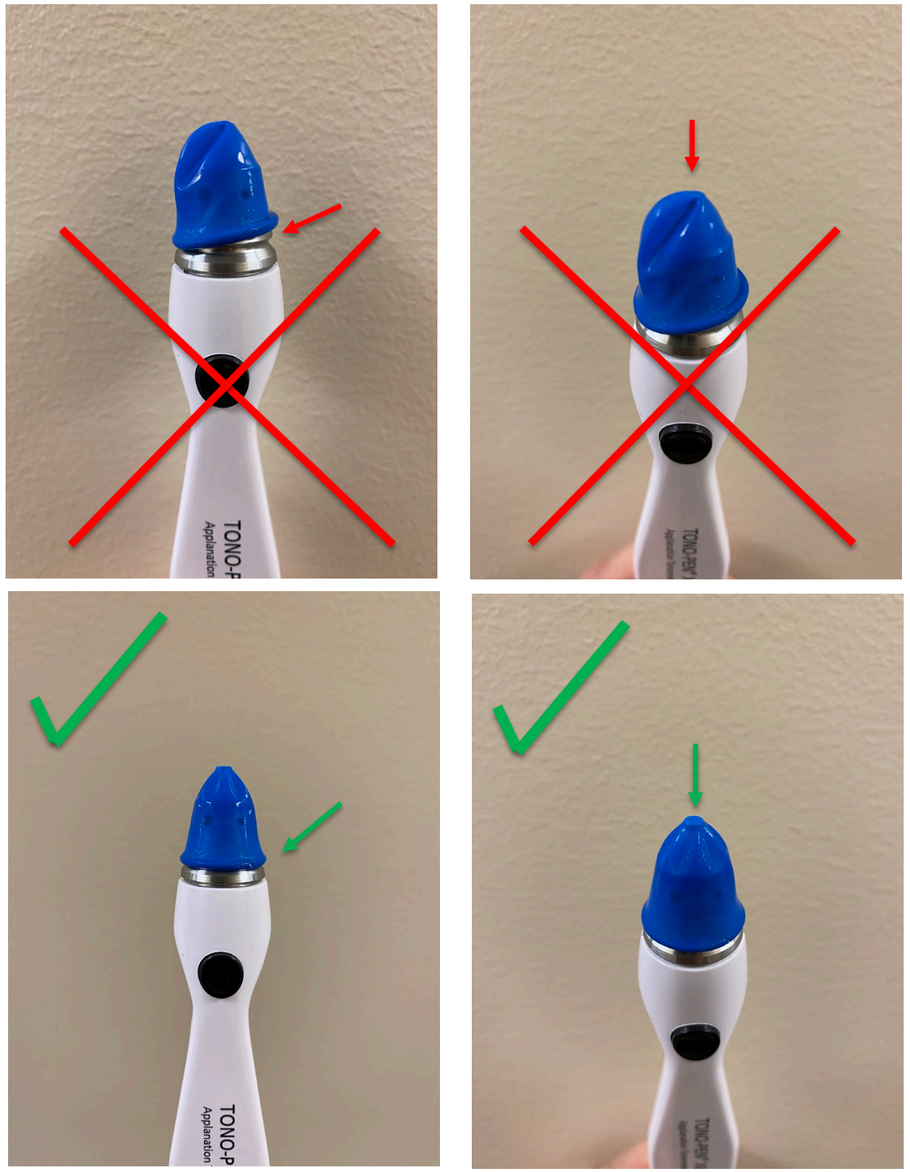
TONOPEN

- **Preparation**
  - Put a drop of anesthetic in the patient's eyes
  - Carefully place a new **rubber Tonopen cover** fully onto the tip of the Tonopen
    - The rubber band at the base of the cover should sit neatly in the groove at the base of the Tonopen tip
    - The tip of the cover should sit flush against the top of the Tonopen tip without air in between



[Source: Modified from photos taken by Sophia Fang at the Moran Eye Center]

TONOPEN

- **Measurement**
  - Press the activation switch to turn the Tonopen on
  - Two dashed bars should appear, which indicates it is ready to measure
  - Hold the Tonopen like a pencil with the tip perpendicular to the corneal surface
  - Rest the heel of your hand against the patient's cheek
  - Press button once and you will hear a beep
  - Carefully touch the tip to the eye and you will hear a click when a measurement is taken
  - **After 3 successful measurements for the straight Tonopen (10 for the curved Tonopen)**, there will be a final beep and an average of the IOP measures will be displayed

[Source: Taken by Vincent Tang at UC Davis Eye Center, Moran Eye Center: http://morancore.utah.edu/basic-ophthalmology-review/intraocular-pressure/]

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TONOPEN INSTRUCTIONS

- **Calibration** (if needed)
  - The Pen should be calibrated if the batteries have been changed or if the display reads "CAL" followed by "- - - -"
  - Point tip of the pen straight downwards
  - Press application button twice
  - "CAL" will be displayed and wait 15 seconds until it says "UP"
  - Turn pen straight upwards
  - If display reads "Good" you can start measurement, but if it says "Bad" then repeat the calibration process
- There are different Tonopen models, but they function similarly

[Source: Taken by Vincent Tang at UC Davis Eye Center, Moran Eye Center: http://morancore.utah.edu/basic-ophthalmology-review/intraocular-pressure/]

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TONOPEN INSTRUCTIONS

- **Storage:**
  - Always store the Tonopen in a way that avoids dust accumulation on the tip
  - Keeping the outer plastic and the inner paper on the new rubber tip cover is an often a universal sign of assurance that the cover is new

[Source: Moran Eye Center: http://morancore.utah.edu/basic-ophthalmology-review/intraocular-pressure/]

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TONOPEN INSTRUCTIONS

[Source: Moran Core, http://morancore.utah.edu/basic-ophthalmology-review/intraocular-pressure/]

RECORDING IOP

- When you measure IOP, record the values for **both eyes**, just as you would for the other "ophthalmic vital signs"
- Include the **time** and **method** used
- Example:

	OD (Right Eye)	OS (Left Eye)
Visual Acuity, distance, SC	20/20	20/20
Pupillary Exam	3mm->2mm, xRAPD	3mm->2mm, xRAPD
Intraocular Pressure (via Applanation at 15:00)	**16 mmHg**	**17 mmHg**
Confrontational Fields	Full	Full
Extraocular Movements	Full	Full

FACTORS THAT AFFECT IOP

- **Accuracy** of Measurement
  - Too much or too little fluorescein dye
  - Not measuring in the center of the cornea
  - Corneal scarring
- **Interpretation** of Measurement
  - IOP can **vary up to 10mmHg** depending on the time of day
  - Baseline IOP for some patients may be **higher** (e.g. thicker corneas)
  - Breath-holding and Valsalva maneuvers can **falsely increase IOP**

[Source: https://commons.wikimedia.org/wiki/File:Valsalva_maneuver.jpg]

FACTORS THAT AFFECT IOP

- Cornea's **rigidity** and **surface tension** are also factors
  - Thinner cornea = actual IOP > measured IOP
  - Thicker cornea = actual IOP < measured IOP
- Recommend:
  - Practice proper technique
  - Encourage patients to **breathe normally** and **relax** during measurement

[Source: https://commons.wikimedia.org/wiki/File:Valsalva_maneuver.jpg]

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