Q

Applanation Tonometry

(*P* is for *Pressure*)

- Based on the [two-name eponym] *principle*: **P = [ ] / [ ]**

A

Applanation Tonometry

- Based on the *Imbert-Fick principle*: **P = F / A**

Q

Applanation Tonometry

- Based on the *Imbert-Fick principle*: **P = F / A**
  - Pressure inside a sphere equals [what the…] [*…F* stands for] divided by the [what the ***A*** stands for]

I-F Principle in words

A

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- Based on the *Imbert-Fick principle*: **P = F / A**
  - Pressure inside a sphere equals force needed to flatten its surface divided by the area of flattening

I-F Principle in words

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  - Pressure inside a sphere equals force needed to flatten its surface divided by the area of flattening
  - Assumes surface is [two words], and [ ] (cornea is neither, obviously)

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- Based on the *Imbert-Fick principle*: **P = F / A**
  - Pressure inside a sphere equals force needed to flatten its surface divided by the area of flattening
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  - Assumes surface is infinitely thin, and dry (cornea is neither, obviously)
    - K thickness→resists applanation→ [increase vs decrease] IOP reading

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For the Imbert-Fick principle to hold, the **only** force resisting applanation should be the pressure within the sphere. However, real objects such as the cornea have *intrinsic* resistance to deformation owing to their physical nature, ie, because they're made of 'stuff.'

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For the Imbert-Fick principle to hold, the **only** force resisting applanation should be the pressure within the sphere. However, real objects such as the cornea have *intrinsic* resistance to deformation owing to their physical nature, ie, because they're made of 'stuff.' This inherent structural resistance of the cornea will be additive to whatever pressure is inside the eye, thereby causing the pressure reading to be falsely **high**. (And the thicker the cornea is, the higher the reading will be.)

Q

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    - Tear film→capillary attraction→ increase vs decrease IOP reading

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On the other hand: The first ocular structure encountered by the applanator tip is the tear film. When contact with the tear film is made, a fluid bridge forms between the cornea and the tip. Surface tension of the water in this fluid bridge produces *capillary attraction*, which exerts a slight 'pull' on the applanator tip, drawing it toward the cornea.

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To be useful, an applanator-type device has to account for these factors.

Fortunately, the brilliant Dr. Goldmann was (mostly) up to the challenge…

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  - Dr Goldmann realized if the diameter of the circle applanated by the device is #.## mm, capillary attraction and corneal thickness would cancel each other out (assuming CCT is # µm)

(CCT = Central corneal thickness)

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    - Goldmann believed CCT was ~520, with little variation

(We now know that CCT *averages* about 550, with wide variation among individuals)

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    - Goldmann believed CCT was ~520, with little variation
    - When the mires line up, the diameter of the applanated area is 3.06 mm

Applanation Tonometry

What happens during applanation tonometry, and how does it measure IOP?

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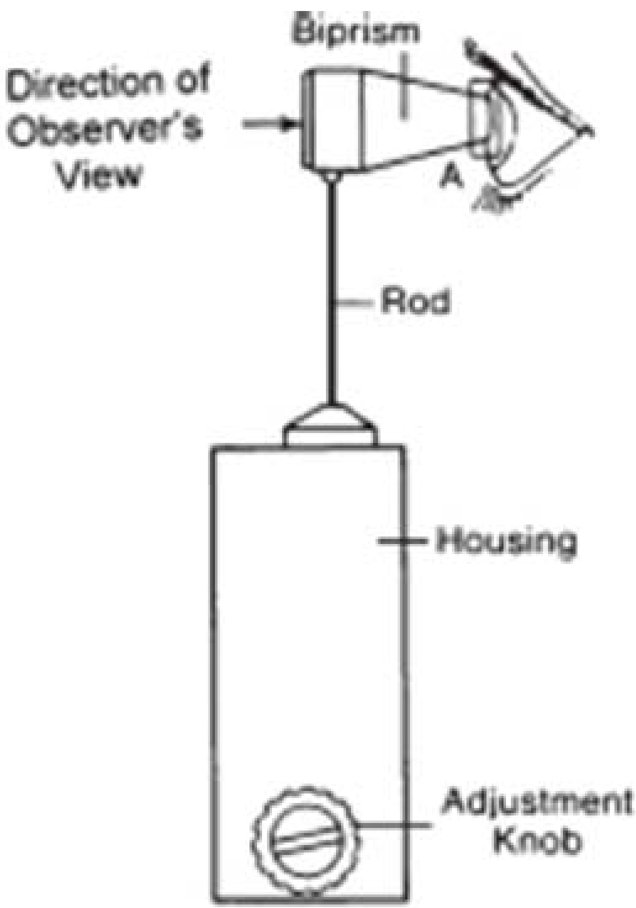
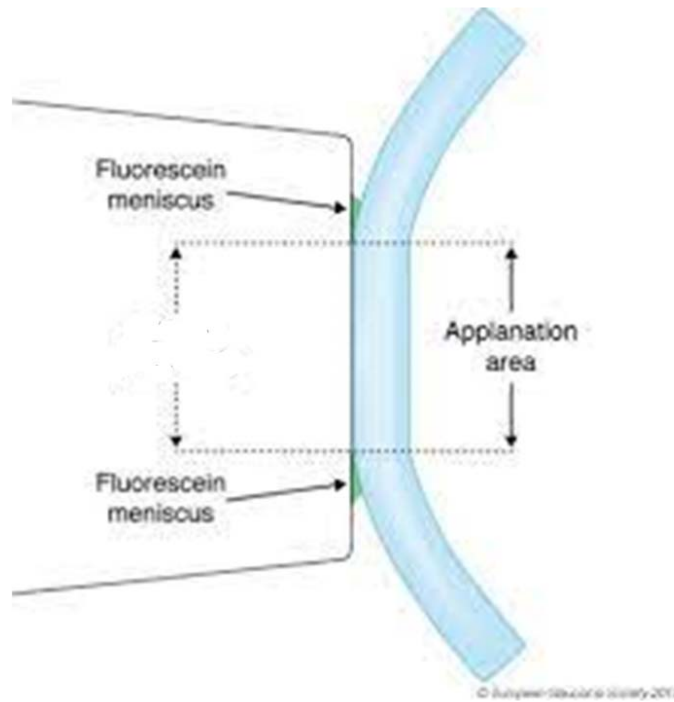
During applanation tonometry, the tip of the applanator pushes against the cornea, flattening it. As the tip flattens the cornea, fluorescein flows into and fills the rim-area between the cornea and the applanator tip, forming a 'meniscus ring.'

- When the mires line up, the diameter of the applanated area is 3.06 mm

Applanation Tonometry





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During applanation tonometry, the tip of the applanator pushes against the cornea, flattening it. As the tip flattens the cornea, fluorescein flows into and fills the rim-area between the cornea and the applanator tip, forming a 'meniscus ring.' The size of this ring is a function of how much the tip is flattening the cornea—if the tip is flattening a large area, the ring will be large; if it's flattening a small area, it will be small. To measure IOP, you must adjust the pressure being applied by the device (ie, turn the knob) until the diameter of the fluorescein circle is exactly 3.06 mm. When this is done, the force being applied by the applanator exactly matches the force on the inside of the cornea—that is, the IOP.

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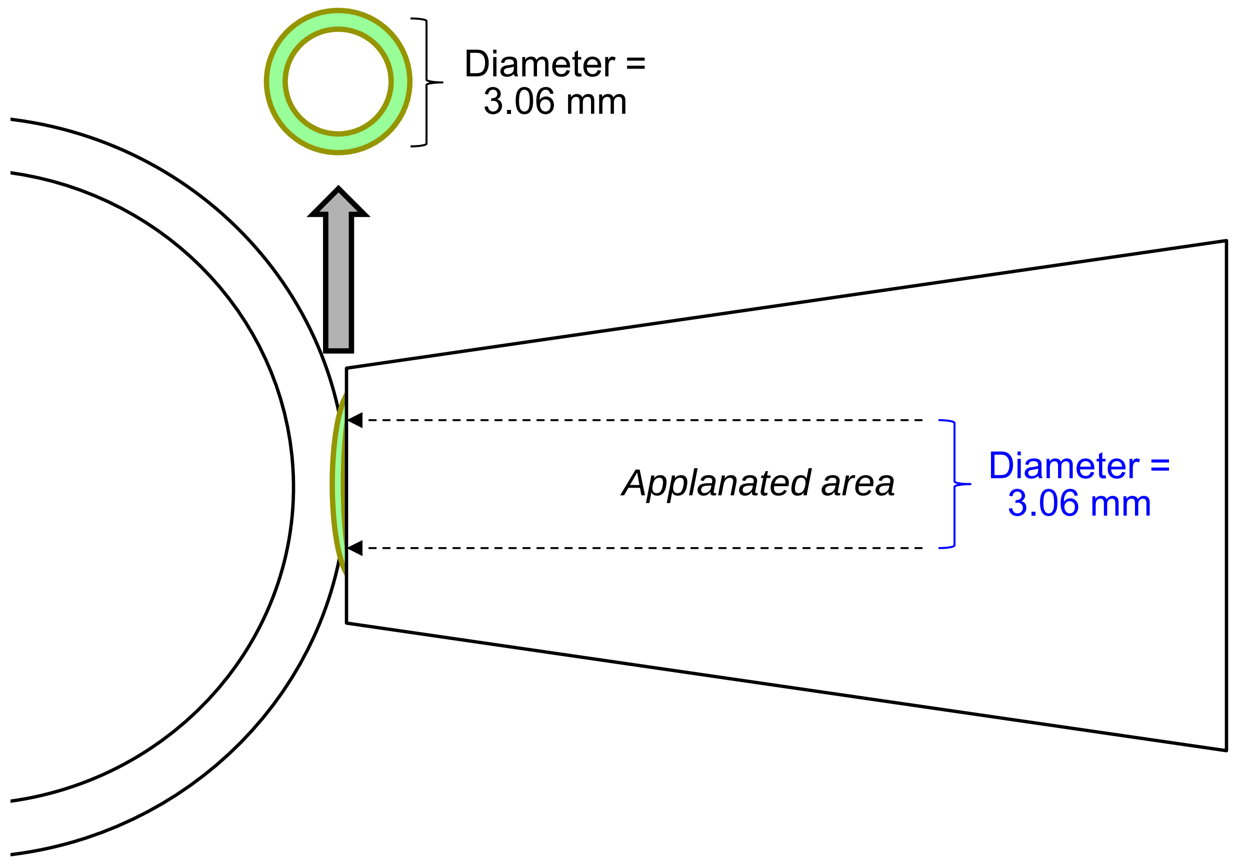
Applanation Tonometry



Applanation tonometry: When the diameter of the flattened area is 3.06 mm, the force being applied by the tip equals the pressure inside the eye

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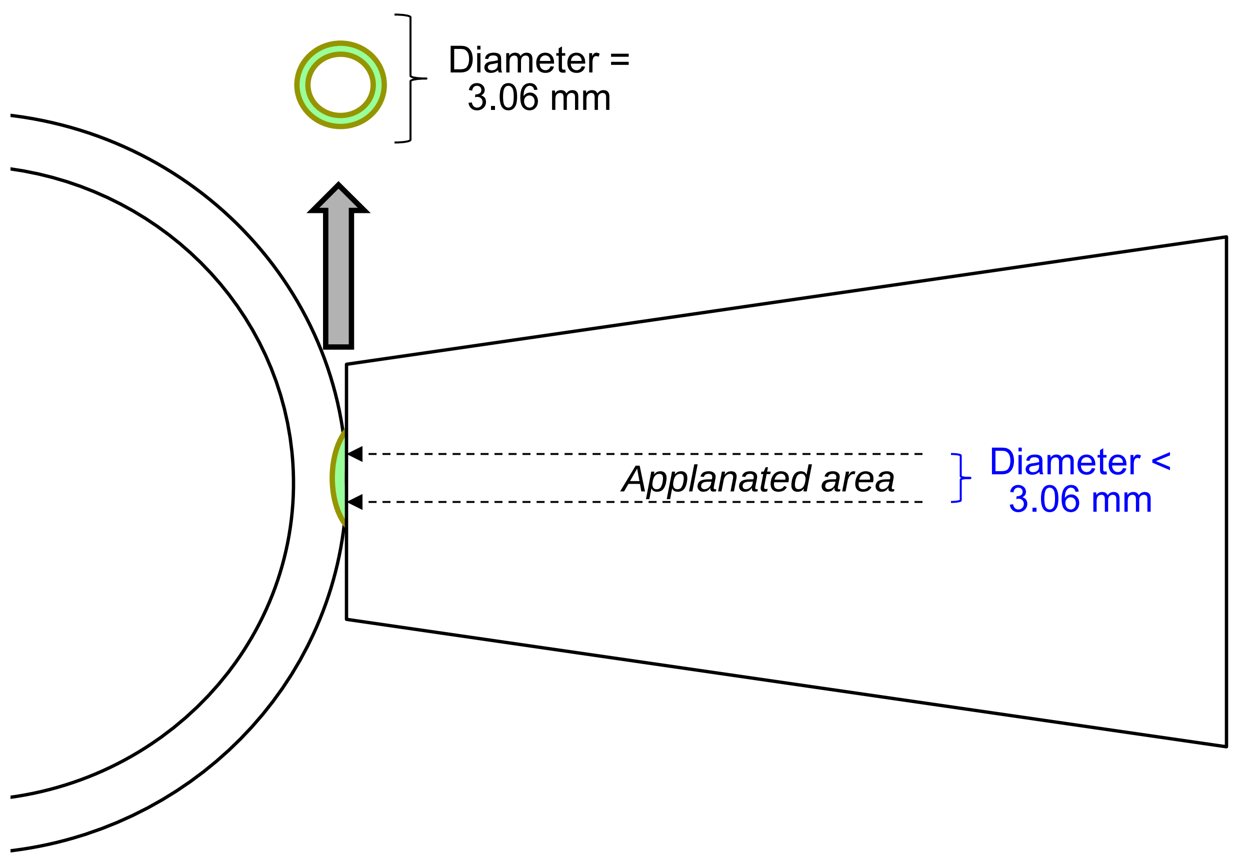

When the diameter of the flattened area is less than 3.06 mm, the force being applied by the tip is less than the pressure inside the eye

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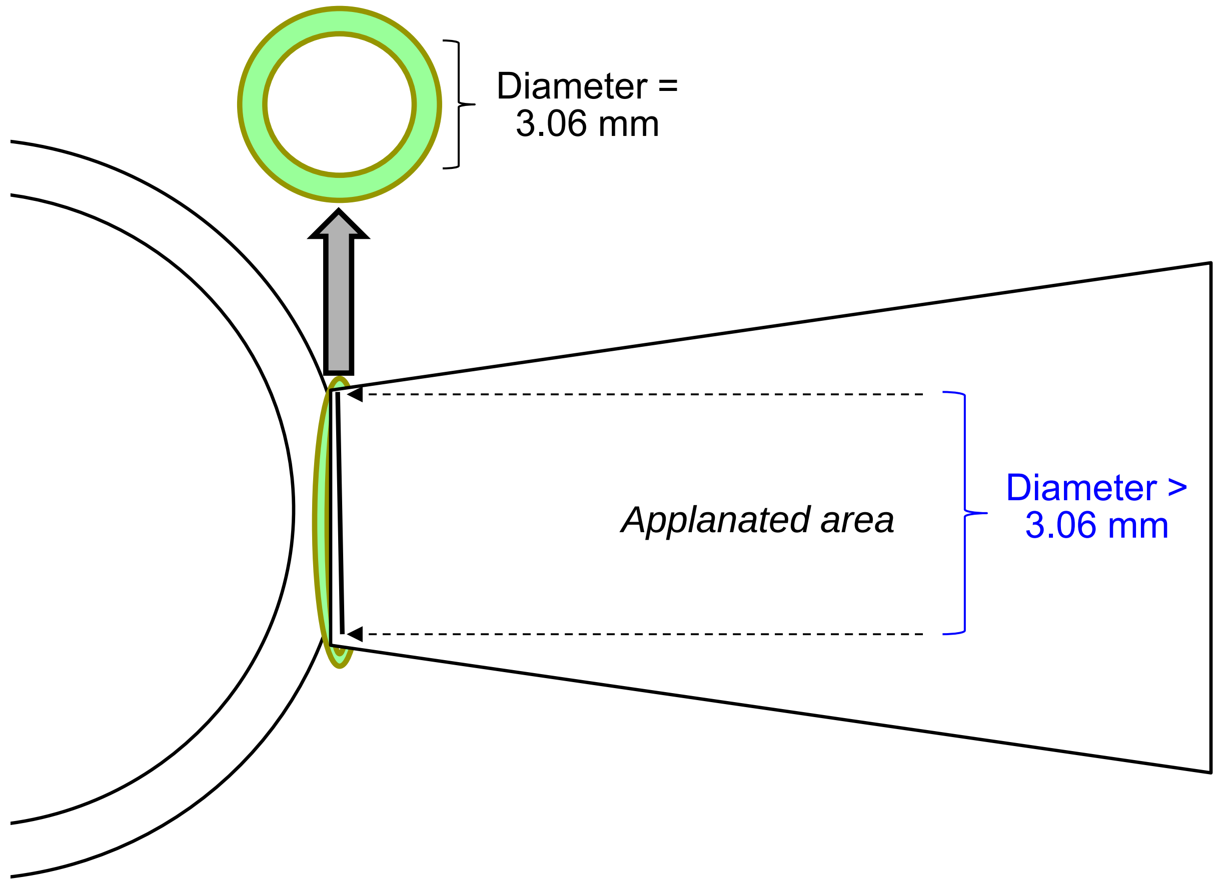
- When the mires line up, the diameter of the applanated area is 3.06 mm

Applanation Tonometry



When the diameter of the flattened area is greater than 3.06 mm, the force being applied by the tip is greater than the pressure inside the eye

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OK, but why does the applanator use a prism to split the circle?

- **When the mires line up, the diameter of the applanated area is 3.06 mm**

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OK, but why does the applanator use a prism to split the circle?
Consider if the applanator didn't contain a prism. The tip would press against the cornea, and you would adjust the knob until the diameter of the circle was 3.06 mm. Seems straightforward enough, until you consider this: How would you know when the diameter is 3.06 mm? One way would be to simply etch a 3.06 mm line into the optics of the slit-lamp. This would provide an easy-to-use measurement tool. OTOH, the line would be visible during the rest of the exam—not good. What else you got?

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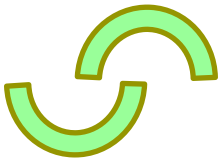
Enter the prism. The prism splits the image of the circle in half, but not in a random way. Rather, the prism is powered so that *the two half-circles will exactly overlap when the diameter of the circle is 3.06 mm.* Thus, as the pressure applied by the tip is manipulated (ie, as you turn the knob on the applanator), it *looks* like the mires are moving toward or away from one another—*but they're not*. What's **actually** happening is *the circle is getting larger or smaller*. (Next time you applanate someone, take note of the heights of the mires as you adjust the knob, and you'll be better able to appreciate the fact that it's the *size* of the circle that's actually changing, not the distance between the segments).

- **When the mires line up, the diameter of the applanated area is 3.06 mm**

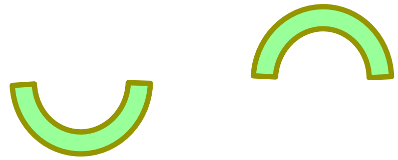
Applanation Tonometry

Dia. of applanated area >3.06 mm



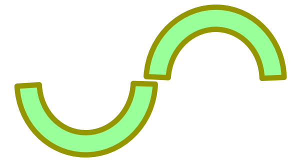
Number on dial is too *high*

Dia. of applanated area < 3.06 mm



Number on dial is too *low*

Dia. of applanated area = 3.06 mm

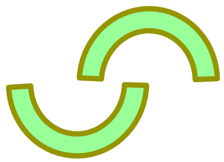


Number on dial = IOP

What you ***think*** *you're seeing when you turn the knob*: One size of ring segment moving closer and farther apart

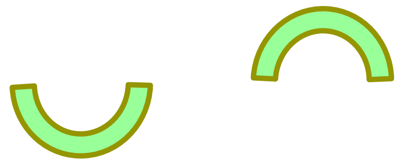
Applanation Tonometry

Dia. of applanated area >3.06 mm



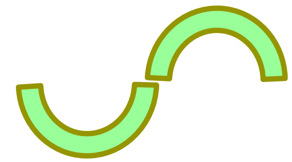
Number on dial is too *high*

Dia. of applanated area < 3.06 mm



Number on dial is too *low*

Dia. of applanated area = 3.06 mm



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What you **think** *you're seeing when you turn the knob*: One size of ring segment moving closer and farther apart

---

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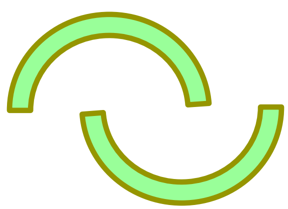
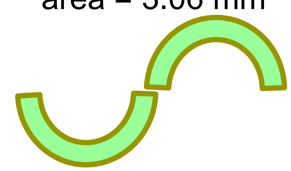


Number on dial is too *high*

Dia. of applanated area < 3.06 mm

Number on dial is too *low*

Dia. of applanated area = 3.06 mm



Number on dial = IOP

What you're **actually** *seeing*: The size of the ring segment getting larger and smaller

Q

Applanation Tonometry

- **More on Applanation Tonometry**
  - Reading will be falsely ***LOW*** if:
    - Cornea is pathologic state

A

- **More on Applanation Tonometry**
  - Reading will be falsely ***LOW*** if:
    - Cornea is edematous

Q

- **More on Applanation Tonometry**
  - Reading will be falsely ***LOW*** if:
    - **Cornea is edematous**

*But an edematous cornea is a thick cornea, and we all know that thicker corneas yield falsely **high** applanation pressures. What gives?*

A

- **More on Applanation Tonometry**
  - Reading will be falsely ***LOW*** if:
    - **Cornea is edematous**

*But an edematous cornea is a thick cornea, and we all know that thicker corneas yield falsely **high** applanation pressures. What gives?*
Not all thick corneas are biomechanically equivalent. A ‘naturally thick’ (i.e., thicker-than-normal in the non-pathologic state) cornea yields falsely high applanation readings because it has greater intrinsic biomechanical resistance compared with thinner corneas.

A

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Not all thick corneas are biomechanically equivalent. A ‘naturally thick’ (i.e., thicker-than-normal in the non-pathologic state) cornea yields falsely high applanation readings because it has greater intrinsic biomechanical resistance compared with thinner corneas. On the other hand, an edematous cornea undergoes a **decrease** in its native biomechanical resistance (think of it as being ‘gooey’). Thickness in and of itself is not the issue.

Q

- **More on Applanation Tonometry**
  - Reading will be falsely ***LOW*** if:
    - Cornea is edematous
    - Applanation performed over a oops

A

- **More on Applanation Tonometry**
  - Reading will be falsely ***LOW*** if:
    - Cornea is edematous
    - Applanation performed over a soft CL *CL = contact lens*

Q

- **More on Applanation Tonometry**
  - Reading will be falsely ***LOW*** if:
    - Cornea is edematous
    - Applanation performed over a soft CL
    - After [two words] surgery (changes scleral rigidity)

A

- **More on Applanation Tonometry**
  - Reading will be falsely ***LOW*** if:
    - Cornea is edematous
    - Applanation performed over a soft CL
    - After scleral buckling surgery (changes scleral rigidity)

Q

- **More on Applanation Tonometry**
  - Reading will be falsely ***LOW*** if:
    - Cornea is edematous
    - Applanation performed over a soft CL
    - After scleral buckling surgery (changes scleral rigidity)
    - Too [much *vs* little] fluorescein in tear film

A

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    - Cornea is edematous
    - Applanation performed over a soft CL
    - After scleral buckling surgery (changes scleral rigidity)
    - Too little fluorescein in tear film

Q

- **More on Applanation Tonometry**
  - Reading will be falsely ***LOW*** if:
    - Cornea is edematous
    - Applanation performed over a soft CL
    - After scleral buckling surgery (changes scleral rigidity)
    - Too little fluorescein in tear film
  - Reading will be falsely ***HIGH*** if:
    - Performed over a two words

A

- **More on Applanation Tonometry**
  - Reading will be falsely ***LOW*** if:
    - Cornea is edematous
    - Applanation performed over a soft CL
    - After scleral buckling surgery (changes scleral rigidity)
    - Too little fluorescein in tear film
  - Reading will be falsely ***HIGH*** if:
    - Performed over a corneal scar

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