



## Improving & Maintaining Wettability in Gas Permeable Lenses

Jason Jedlicka OD, FAAO, FSLS


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### Speaker Bio – Dr. Jason Jedlicka

- Associate Professor at Indiana University School of Optometry
- Chief of Cornea and Contact Lens Service
- 2021 GPLI practitioner of the year
- Past President of the Scleral Lens Education Society
- Diplomate in Cornea, Contact Lens and Refractive Technologies Section of the AAO
- Fellow and Board Member of the Contact Lens Society of America




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### Financial Disclosures for Dr. Jedlicka

- Consultant to Bausch and Lomb
- Consultant to Oculus
- Consultant to Eaglet Eye
- Honorarium from Essilor, Tangible Sciences

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# What is Wettability?

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### Wettability

Wetting is the ability of a liquid deposited on a surface to spread out and maintain contact with that surface

Poor Wetting → Excellent Wetting

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### Surface Wetting – Basic Concepts

- Wetting is promoted by a relatively high surface free energy of the solid and a relatively low surface tension of the liquid.
  - High surface free energy = metals, glass
  - Low surface free energy = polymers
- Contact lens polymers have a low surface free energy, in general, which means we are fighting that battle from the outset

High Surface Energy      Low Surface Energy

Easy      To Bond to      Difficult

- Water has a relatively high surface tension
  - So water on a contact lens polymer tends to be a bad combination
- Human tears have a lower surface tension than water due to the various components

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### Surface Wetting – Basic Concepts

- To improve surface wetting:
  - Increase surface free energy
    - Can materials make much of a difference?
  - Alter the surface of the material
    - Coat the material in something that has a higher free energy
  - Lower the surface tension of the fluid
    - Add something to the fluid or alter its composition to lower tension
      - Surfactants

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### Why Is Wettability Important in Contact Lenses?

- A non-wet surface decreases vision through the lens
- A non-wet surface increases allows deposits to attach to the lens surface more easily
- A non-wet surface increases friction with the lid wiper which creates symptoms

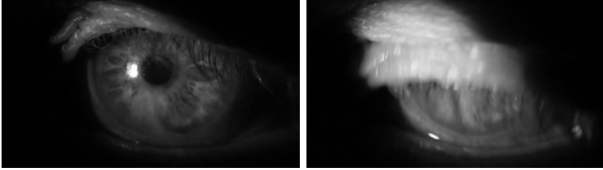
Dry eye states and/or contact lens surfaces  
↓  
Inadequate lubrication  
↓  
Mechanical trauma to epithelium of lid wiper  
↓  
Staining of epithelium of the Lid Wiper  
↓  
Tissue Response of Lens  
↓  
Inflammatory cascade  
↓  
Squelcher

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### Why Is Wettability Important in Contact Lenses?

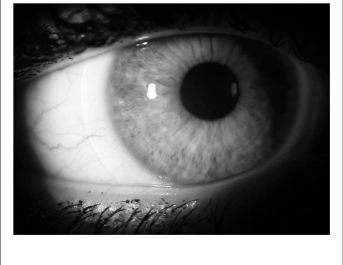
- So a wetting surface provides
  - Better, more stable vision
  - A cleaner, less deposited, and in theory, longer lasting lens
  - Less symptoms of dry eye and less likelihood of triggering a dry eye cascade



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### How Does Wetting Occur?



- The upper lid wiper distributes the tear layer components over the ocular surface
- The lower lid has very little movement in a typical blink
- Therefore to get good tear distribution, the upper lid should come down into contact with the lower lid / tear meniscus to grab tears to distribute, and the upper lid wiper should be in good condition to distribute the tears properly

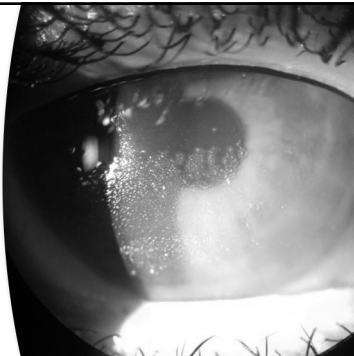
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### When Proper Blinking Does Not Occur

Lens surface dries, which allows deposits to begin to form and anchor to the lens

Can be due to poor blink habits (acquired through years of contact lens wear or device use?) or poor blink function (prior lid surgeries, trauma, paralysis or palsy)



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## Contact Lenses Materials, Cleaning, and Coating: their Impact on Wettability

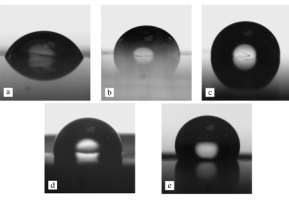
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### Contact Lens Wetting - Materials

- How much does the material matter when it comes to wetting?
  - Certainly, there are differences – water on:

- A) **PMMA**
- B) Polycarbonate
- C) Polypropylene
- D) **Silicone**
- E) Poly(tetrafluoroethylene)



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### Rigid Contact Lens Materials

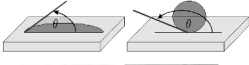
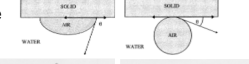
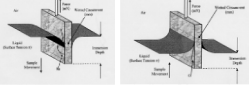
<p><b>PMMA - POLY (METHYL METHACRYLATE)</b></p> <ul style="list-style-type: none"> <li>• ORIGINAL "HARD" LENS MATERIAL</li> <li>• RELATIVELY HYDROPHILIC</li> </ul>	<p><b>Silicone/Acrylate (S/A)</b></p> <ul style="list-style-type: none"> <li>• First GP materials</li> <li>• Contain Silicone Methacrylate, wetting agents, and cross-linking agents</li> <li>• Silicone is Hydrophobic – so wetting is negatively affected</li> <li>• Wetting and cross-linking agents are required to neutralize the hydrophobicity and flexibility of silicone</li> </ul>	<p><b>Fluoro-Silicone/Acrylate (F-S/A)</b></p> <ul style="list-style-type: none"> <li>• Addition of fluorine to the S/A components, which acts like teflon on the surface</li> <li>• Fluorine reduces deposits and aids in wettability as well as improving oxygen transmission</li> <li>• Deposit resistance and improved wettability over S/A materials</li> </ul>
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What is the difference in wettability? How do we measure this to know?

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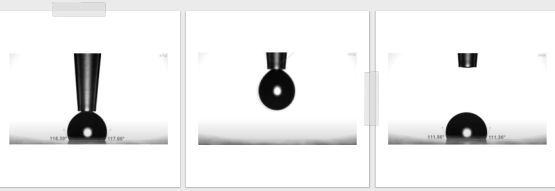
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### 3 Methods for measuring wettability

1. Sessile Drop (in air)
 
2. Captive Bubble (in water)
 
3. Wilhelmy Plate Technique (dynamic in water)
 

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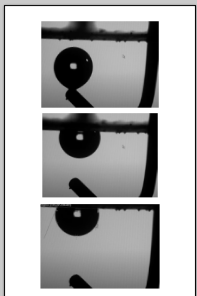
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### Sessile Drop

Done in air by dropping a precise volume of fluid onto a surface  
Easiest to perform, but can be influenced by evaporation

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### Captive Bubble

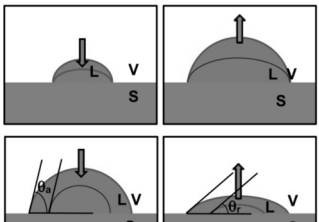
- The material is submerged in water (or fluid) and an air bubble is brought into contact with the surface
- More "accurate" but harder to perform
- Bubble release can sometimes be challenging

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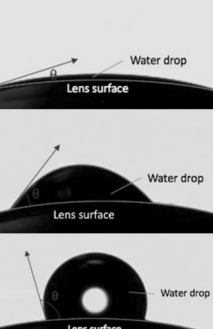
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### Dynamic Captive Bubble

- Measures advancing and receding angles by changing the size of the air bubble
- Some polymer manufacturers use this technique as well
  - Probably more accurate, but time consuming and challenging to perform



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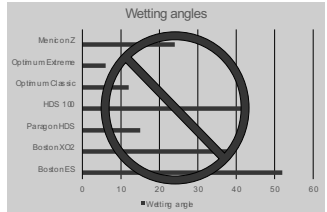
### Wetting Angles

- The lower the wetting angle in general, the better the liquid will distribute of the lens surface
- Wetting angles can be difficult to truly gauge and compare due to variations in technique even within the methods and controls in the testing environment
  - Contact lenses are not flat surfaces
  - The polymer may not be truly homogenous in its surface

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### Wetting angle

- Cannot really compare wetting angle of GP materials across manufacturers as they use different methods for measuring
- We spend a lot of time overthinking this aspect of our contact lens wetting issues and I think it is relatively pointless, the differences are just not that significant
- My personal experience is not consistent with these published numbers...



Model	Wetting angle (approx.)
MentonZ	15
Optimum Extreme	15
Optimum Classic	15
HDS 1.0	15
PurigenHDS	15
BostonXC2	15
BostonES	15

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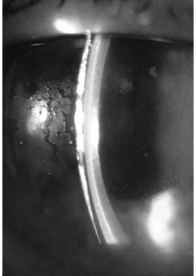
### Other Than Polymer Differences, What Impacts Wetting?

- Lens surface condition
  - Manufacturing a lens can create residue
  - Wear of a lens can lay down deposits on a lens surface that impact wetting

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### Lens Wetting Post Production

- Lenses may have pitch or waxy residue from the production process
- Plasma treating helps remove this more thoroughly
- Cleaning and conditioning a lens when it arrives in office can make a big difference if a lens is shipped dry




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### Lens Wetting Post Production

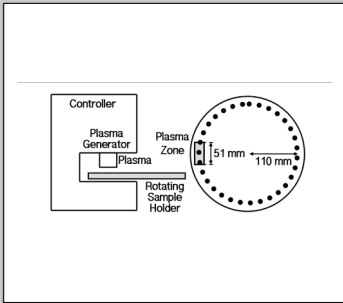
- To avoid immediate non-wetting of a new lens, vigorously rub lenses in conditioning solution prior to application
- In the case of a scleral lens, rinse off excess conditioner prior to filling, but consider conditioning the applicator/plunger prior to putting the lens on the tool
- The physical act of rubbing the lens helps bond the wetting agent to the lens surface temporarily allowing better initial wetting



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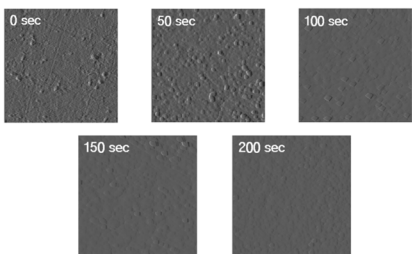
### Plasma treatment

- A gas that is ionized into a mixture of highly reactive negatively and positively charged particles
- During treatment, GP lenses are placed in a vacuum chamber, where oxygen plasma breaks up and removes surface contaminants including grease, lipids and other residues



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### Plasma treatment

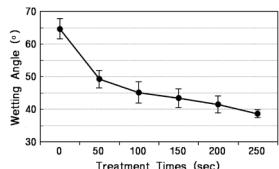


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### Plasma treatment

#### Impact on Surface Wetting



Treatment Times (sec)	Wetting Angle (°)
0	~65
50	~50
100	~45
150	~43
200	~41
250	~38

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### Plasma treatment

- Is there any alteration to the lens beyond "hypercleaning"?
- Some publications suggest there is a silica-like coating that forms as a result of removal of carbon based imperfections allowing oxygen and silicone to create silica
- Does help initial wettability and "cleanness" out of the gate

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### Surface Coatings - HydraPEG

- Biocompatible Polyethylene glycol-based polymer mixture
- Covalently bonded to lens surface
- Hides underlying lens material from ocular surface
- Reduces wetting angle dramatically

Contact lens with HYDRAPEG Covalently Bonded Surface

Polymer surfacing attracts water

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Sessile Drop Test on GP Lens Coated with PEG

Sessile Drop Test on Uncoated Lens

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### Surface Coatings - HydraPEG

- Improves wettability by creating a more hydrophilic surface for the tear layer
- Increases lubricity to reduce friction

Surface Wettability

Material	Maximum Contact Angle (Degrees)
Silicone Elastomer	~105
Silicone w/ Hydra-PEG	~35
Baklar (B&L)	~95
Omni (LNO)	~65
Stativity (Comper)	~60
Total 1 (Allco)	~45

Lubricity Chart

Material	Digital Lubricity (Ct & units)
Silicone Elastomer	~1.5
Silicone w/ Hydra-PEG	~5.5
Perfection (B&L)	~2.5
Tufolex (LNO)	~2.5
All Stars (Allco)	~3.5
Baklar (B&L)	~3.5
Stativity (Comper)	~3.5
Total 1 (Allco)	~5.5

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### Surface Coatings - HydraPEG

- Minimizes protein and lipid deposition
  - Which in turn maintains wettability over time

Protein Deposition

Protein Incubation Time	Uncoated Lens	Plasma-Treated Lens	Treated with Tangible® Hydra-PEG®
1hr	~15	~10	~5
2hr	~25	~15	~5

Uncoated Lens   Plasma-Treated Lens   Treated with Tangible® Hydra-PEG®

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### With and Without HydraPEG coating

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### With and Without HydraPEG coating

PEG coating is the DEFINITIVE way to lower the surface wetting angle and improve lens surface wetting

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### HydraPEG Coating – Questions

- How long does it last?
- Is it permanent?
- Can it be removed?
- Normal "wear and tear", cleaning and handling seem to reduce the efficacy of the HydraPEG over months of lens use
- To maintain the coating, a treatment was developed to repopulate the surface with more polyethylene glycol

Coated lenses require proper care to not damage the coating and reduce its effectiveness

Use non-abrasive cleaners  
Peroxide systems  
No harsh chemicals such as Progent

In reality, these cleaners should not be required as the wetted lens surface helps to retard deposits

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### Recoating the HydraPEG coated lens

- BOOST - In home monthly treatment
- RX ONLY
- 30 Minute treatment

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### Recoating the HydraPEG Coated Lens

*"I had a chance to try out the product, Tangible boost. It helped! The contacts felt less noticeable. Usually I have to take them out by late afternoon and felt them throughout the day which is irritating, but not painful like the inflammation/ulcerations I had. With Boost its much less so. I would like to continue using it."* - DK

Category	Number of Eyes
Tangible Hydra-PEG	25
Uncoated	6
No Difference	5

\*Compared to Habitual Lenses

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### Care of Lenses and Wettability

- Cleaning
- Keeping the surface wetted
- Surfactants

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### GP lens surface issues

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### Cleaning Basics


- Removal of loose bonded particles
  - Cell debris
  - Tear components
    - Lipids, mucous, proteins
  - Anorganic deposits
    - Calciums, iron
  - Cosmetics
  - Microorganisms



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### Cleaning basics

- Alcohols
  - Stronger but harder to find
- Surfactants
  - Safe on all GP materials but perhaps less effective?
- Abrasives
  - Used typically only with older more durable materials
  - Not as easy to find anymore
  - Boston original cleaner is an example
- Enzymatic cleaners
  - Proteases (breakdown of proteins)
  - Lipase (breakdown of lipids)
  - Amylase (breakdown of mucins)



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### GP cleaners



- Boston original cleaner
  - Not readily available any longer
  - Abrasive
- Boston advance cleaner
  - Surfactant
  - Microabrasives
- Optimum by loBob Extra strength cleaner
  - Surfactant
  - Currently unavailable
- Sereine cleaner
  - Alcohol based




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### GP Cleaners



- Progent
  - Loosens protein deposits on GP lenses
  - For monthly use
  - The mixture of two sterile solutions, PROAGENT A (sodium hypochlorite, sodium carbonate, sodium hydroxide, purified water) and PROAGENT B (potassium bromide, sodium carbonate, purified water)
  - PROAGENT A and B are mixed in a PROAGENT vial
  - Allow lenses to soak in the PROAGENT solution mixture for 30 minutes. Soaking for longer than 30 minutes is not recommended.

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### GP disinfecting solutions



- Boston Advance Conditioner
  - Wetting agents:
    - polyvinyl alcohol (PVA)
    - cellulosic viscosifier
    - polyethylene glycol
- Sereine wetting and soaking
  - Wetting agent
    - Amphoteric

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### Multipurpose solutions

- Boston Simplus
  - Contains:
    - (surfactant) poloxamine 1107
    - (protein remover) hydroxyalkylphosphonate
    - (preservatives) chlorhexidine gluconate and PAPB
    - glucam-20 and hydroxypropylmethylcellulose (HPMC) for cushioning and wetting
  - Product guidelines recommend that lenses be removed every night and directly in solution; in the morning, the lens should be rubbed gently on either side for 20 to 30 seconds and rinsed prior to lens insertion.





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### Multipurpose solutions

- Unique PH
  - Contains hydroxypropyl guar, polyethylene glycol, tetrionic 1304, boric acid and propylene glycol to aid in cushioning and wettability.
  - Rub & rinse after removal, soak, rinse again prior to application




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### Multipurpose solutions

- Tangible clean
  - Poloxamer as a wetting agent
  - Also contains sodium phosphate buffer, sodium chloride, and disodium edetate




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### Peroxides

- Clear Care
  - 3% hydrogen peroxide for disinfection
  - Poloxamine derivative as a surfactant to help wetting
- A rubbing step should be done still for proper surface cleaning
  - *"Not Rubbing and using either Hydrogen Peroxide or Povidone Iodine solutions, is not effective in removing stubborn deposits from ortho-k lenses."* Cho P, Poon H, Chen C, Youn L. To rub or not to rub? effective rigid contact lens cleaning. *Optometric Physical Opt*. 2020 Jan;40(1):17-23. doi: 10.1111/optn.12600. Epub 2019 Nov 21.



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### Cleaning and Storage Solutions

- Always ensure proper use of cleaning agents with patients
- Sometimes patients are not following all the steps correctly
- Rarely are wetting problems truly about the material, solution, or lens manufacturing
- Focus on the tear layer and surface treatments and maintaining those surface coatings over time with recoatings

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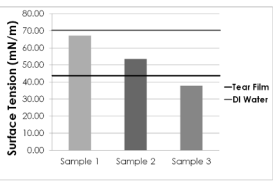
# Ocular Health and Wettability

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### The Tear Layer and Wettability

- Half of the wettability equation is the contact lens surface, the other half is the tear layer
- Increased surface tension, decreased volume, and impaired tear distribution impact lens surface wetting
- *"In a person suffering from dry eye, the surface tension of the tear membrane is found to be somewhere between 44 nM/m to 53 nM/m. Conversely, optimal tear film stability is found to be between 40 nM/m to 46 nM/m."* Centre for Industrial Rheology



Sample	Tear Film (nM/m)	DI Water (nM/m)
Sample 1	~68	~40
Sample 2	~52	~40
Sample 3	~38	~40

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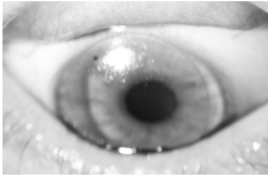

### Dry Eye and Lens Wetting

- Adding lubricant eye drops can be helpful then in improving lens wetting
  - Finding the right viscosity matters
    - Too high and creates blur and FB sensation
    - Too low and it has no residence time between blinks
  - Decreasing surface tension TOO MUCH causes a non-homogenous tear layer thickness on the eye
- Surfactants can lower surface tension of the tear layer by creating more tear component mixing

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### GP Lens Non-wetting

- 53 yo female presents for follow up of persistent lens non-wetting
- New lenses ordered x 2, new cleaning solutions recommended – all with no improvement

Lid everted and lissamine stained

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### Corneal GP Wear and the Impact on Wettability

- Many GP wearers have compromised blinking due to adaptation so as to reduce lens awareness



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### Corneal GP Wearers

- Make the lens as comfortable as possible to as to encourage proper blinking
- Remind of the need to fully blink
- Make sure the patient uses lubricant drops throughout the day
- PEG coating keeps the lens surface wetted even when blinking is compromised

• *“Set aside five – one minute sessions a day for two weeks spread throughout the day. Into each of the minutes, cram fifty full blinks – look into each of the five forward directions (up, down, left, right, straight) blink ten times into each direction (5x10) it takes far less than fifty seconds; much less than a minute. These blinks are not tight lid-squeezes, but closures. It is best to do them with RGP’s in place – to get the feel of it.” - Bezalel Schendowich, O.D.*

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### Scleral Lenses and the Impact on Wetting

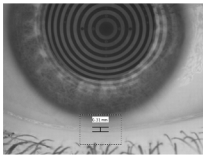
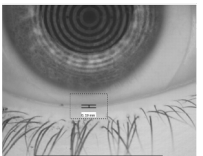
- 51 yo male with a history of scleral lens use in one eye only



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### Ocular Surface and Wettability ISSUES

- How does putting a liquid reservoir over the corneal surface impact the feedback mechanism to the brain that governs basal tear production?

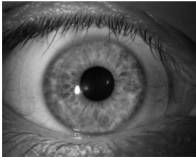



After 15 minutes in a scleral lens

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### Ocular Surface and Wettability ISSUES

- Remember that wearing a scleral lens increases the surface area of the ocular surface that is exposed by increasing the palpebral aperture
  - Puts increased demand on the tear layer



S.D. Shah-Desai, S.A. Aalam, K. Pullum, M. Beaconsfield, G.E. Rose  
 Scleral contact lens usage in patients with complex blepharoptosis  
*Ophthalmic Plast Reconstr Surg*, 27 (2011), pp. 95-98

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### Scleral Lenses

- Increase friction on the lid wiper
- Decrease basal tear production
- Increase aperture to stress the tear layer
- Manage by:
  - Lubrication with lenses in place
  - Manage all scleral lens patients as dry eye patients
  - Keep lens vault low when possible
  - PEG coating on lenses to reduce friction and hold tears in place
  - PEG recoating should be done on a monthly basis particularly in patient with ocular surface disease

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### Summarizing Wetting of GP Lenses

- Many times we think non-wetting is a material or manufacturing problem
- Most of the time it is either the patient's bad habits, dry eye disease, or lid wiper problems
- Make sure the patient learn proper technique for care including **rubbing lenses and using the right solutions properly**
- Make sure you **manage bad habits** like **poor blinking or improper care** regimens and make sure the lens is made as comfortable as possible for the patient so they don't try to adapt out of blinking
- Add lubricants / surfactants** to the patients daily routine
- Plasma treat** lenses to ensure they are as clean as possible out of the gate
- Surface coat lenses with **HydraPEG** to significantly lower wetting angle and reduce friction so as to spare the lid wiper health
- Maintain the HydraPEG with proper care solutions and repopulating the coating monthly with **Boost**
- Aggressively treat lid wiper epitheliopathy when found

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# Thank you!

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Thank you! Please join us for our next COPE event



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 Date: Thursday, October 7, 2021  
 Time: 5:30 PM Pacific Time

Don't Wait, REGENERATE!  
 HOW TO USE REGENERATIVE TOOLS IN EYE CARE

COPE Undergoing approval for 1 hour of live CE credit

Date: October 7, 2021  
 Time: 5:30 pm PST  
 Speaker: Dr. Scott Hauswirth  
 Topic: Don't Wait, REGENERATE!  
 How to use Regenerative Tools in Eye Care  
 COPE: One hour live CE

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