CONTACT LENSES AND DRY EYE: THE IMPACT OF SOFT LENS WEAR ON OCULAR SURFACE HOMEOSTASIS

Cory J. Lappin, OD, MS, FAAO

The Dry Eye Center of Ohio

© 2026 Dr. Cory J. Lappin

FINANCIAL DISCLOSURES

- AbbVie
- Alcon
- Barti
- Bausch + Lomb
- Bruder Healthcare and M&S Technologies (Hilco Vision)
- CSI Dry Eye Software
- Dompé Pharmaceuticals
- Eyederm
- Eyenovia
- EyePromise/PRN
- Harrow
- Lumenis
- Meivertor
- Myze
- Nordic Pharma
- Norwood Device & Diagnostics
- NuLids
- Ocubio
- Rinsada
- SCOPE Health Inc
- Sight Sciences
- Sydnexis
- Tarsus Pharmaceuticals
- TearRestore
- Viatris Pharma (Oyster Point Pharma)
- Vital Tears

ALL RELEVANT FINANCIAL RELATIONSHIPS HAVE BEEN MITIGATED. THE CONTENT OF THIS ACTIVITY WAS PLANNED AND PREPARED INDEPENDENTLY BY DR. CORY LAPPIN WITHOUT INPUT FROM MEMBERS OF AN INELIGIBLE COMPANY.

HOMEOSTASIS

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

Homeostasis

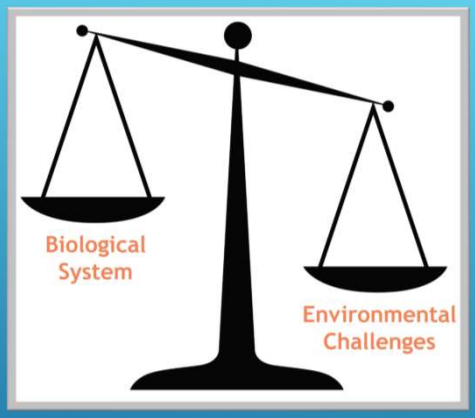
DEFINITION: A SELF-REGULATING PROCESS BY WHICH BIOLOGICAL SYSTEMS MAINTAIN STABILITY WHILE ADJUSTING TO CHANGING EXTERNAL CONDITIONS

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

Dynamic Equilibrium

- **State of balance**
  - Resists change
  - Continuously adjusted
  - Adapts to external challenges
- **Inability to maintain homeostasis**
  - **Disease and Death**



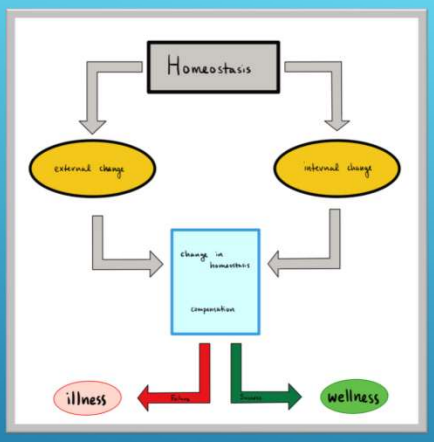
HOMEOSTASIS

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

Feedback-Dependent Control

- Self-regulated
- Complex and integrated
  - Inputs from multiple systems
  - Can be modified by higher level control



HOMEOSTASIS

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

Homeostasis

"DRY EYE IS A MULTIFACTORIAL, SYMPTOMATIC DISEASE CHARACTERIZED BY A LOSS OF HOMEOSTASIS OF THE TEAR FILM AND/OR OCULAR SURFACE, IN WHICH TEAR FILM INSTABILITY AND HYPEROSMOLARITY, OCULAR SURFACE INFLAMMATION AND DAMAGE, AND NEUROSENSORY ABNORMALITIES ARE ETIOLOGICAL FACTORS."

- TFOS DEWS III Diagnostic Methodology Report

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

SOFT CONTACT LENS WEAR & OCULAR SURFACE HOMEOSTASIS

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

SOFT CONTACT LENSES: A HOMEOSTATIC CHALLENGE

Benefits:

- Refractive
  - Vision correction
- Therapeutic
  - BCL
- Interventional
  - Myopia management

Challenges:

- Innately disrupts homeostasis
  - Foreign body on the ocular surface
  - Disrupts tear film
  - Intrinsically inflammatory
- Complications
  - Infection
  - Inflammation

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

UP TO 51% OF CONTACT LENS WEARERS ULTIMATELY END UP DISCONTINUING USE

20% dropout within the first year of wear

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

WHY DOES THIS HAPPEN?
WHAT CAN WE DO TO AVOID IT?

© 2026 Dr. Cory J. Lappin

THINGS TO KEEP IN MIND

- Conflicting findings
- No consensus on many points
- Some effects more historical

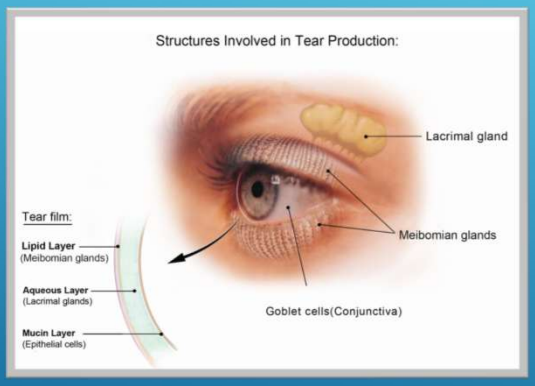
BUT

- General trends have emerged

© 2026 Dr. Cory J. Lappin

SOFT CONTACT LENS WEAR & THE OCULAR SURFACE

© 2026 Dr. Cory J. Lappin



OCULAR SURFACE

- Cornea
- Conjunctiva
- Eyelids & Lashes
- Meibomian Glands
- Main & Accessory Lacrimal Glands
- Goblet Cells
- Tear Film

© 2026 Dr. Cory J. Lappin

Function

- Protection
- Tear spread

LIDS & LASHES

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

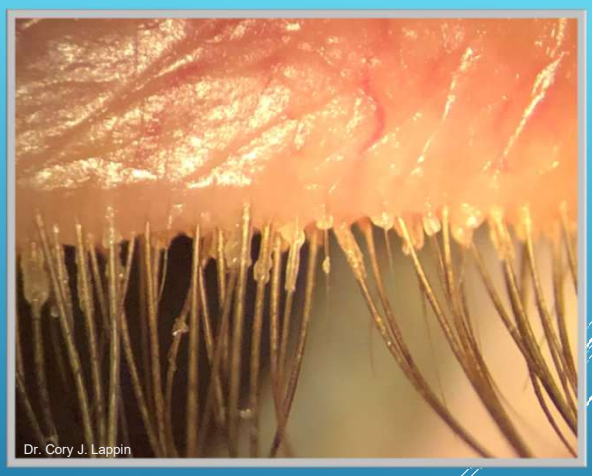
- **Lens Impact on Surface**
  - Increased blink rate
  - Increased incidence of ptosis
- **Surface Impact on Lens**
  - Bacterial blepharitis
    - Saponification

SOFT CONTACTS LENSES: LIDS & LASHES

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

- **Lens Impact on Surface**
  - Increased blink rate
  - Increased incidence of ptosis
- **Surface Impact on Lens**
  - Demodex blepharitis
    - Collarettes
    - **51% of CL wearers have Demodex**
    - **93% of CL wearers experiencing CL intolerance had DB**



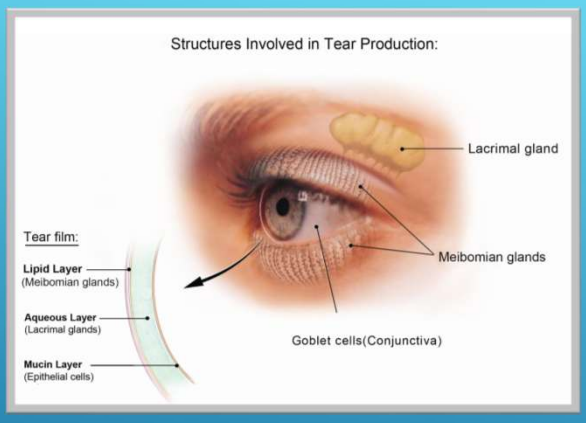
SOFT CONTACTS LENSES: LIDS & LASHES

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

Function

- Protection
- Nourishment
- Smooth optical surface
- Refract light

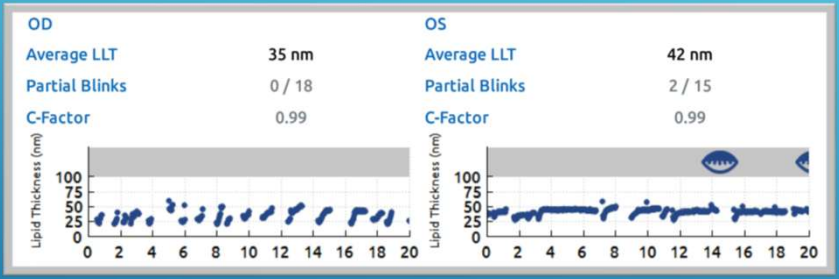


TEAR FILM

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

- **Lens Impact on Surface**
  - **Splits tear film into two**
    - Pre-lens tear film
    - Post-lens tear film
  - Reduced
    - Lipid layer thickness
    - Tear volume
    - Tear film turnover
    - TBUT
  - Increased
    - Evaporation
    - Osmolarity

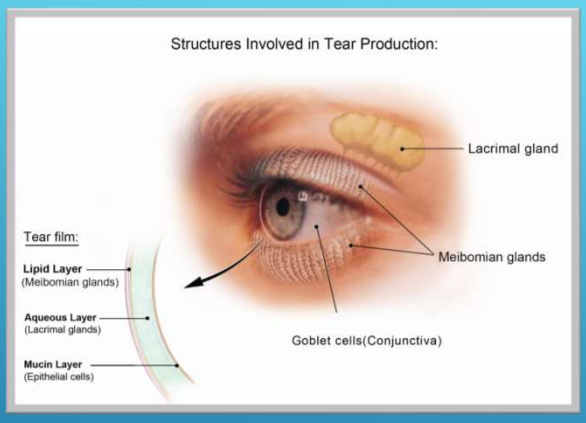


SOFT CONTACTS LENSES: TEAR FILM

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

- **Surface Impact on Lens**
  - Poor tear quality reduces
    - Comfort
    - Wear time
    - Visual quality
  - Lens dehydration
    - Tightening



SOFT CONTACTS LENSES: TEAR FILM

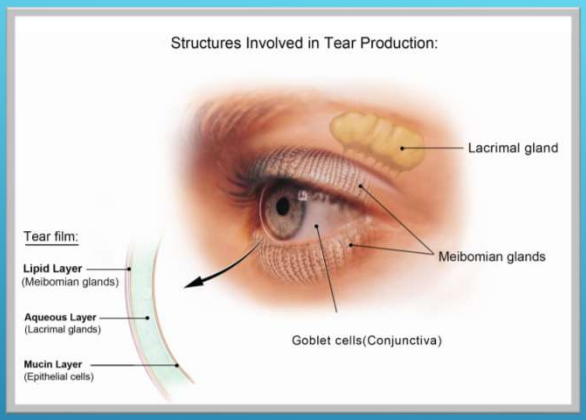
© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

MEIBOMIAN GLANDS

Function

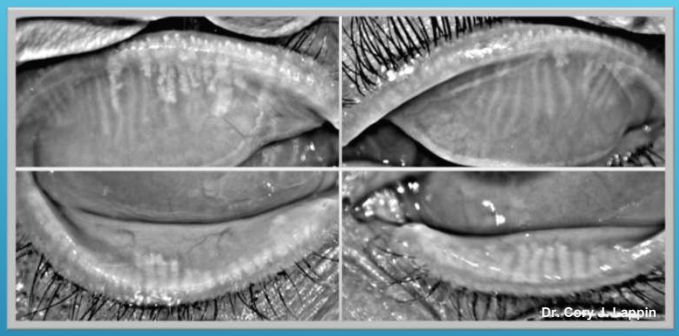
- Produce meibum component of tear film
  - Prevents evaporation
  - Provides smooth optical surface
  - Lowers surface tension



© 2026 Dr. Cory J. Lappin

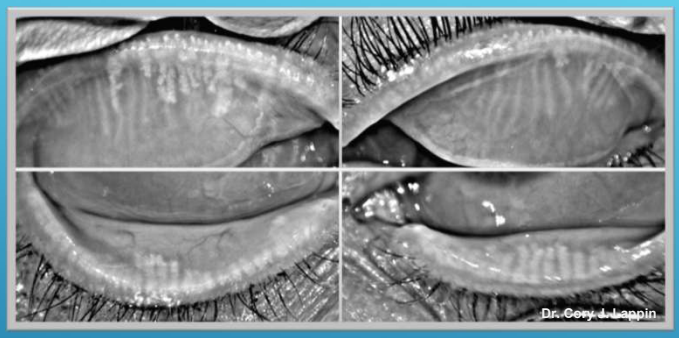
SOFT CONTACTS LENSES: MEIBOMIAN GLANDS

- **Lens Impact on Surface**
  - **Altered meibum quality**
    - Higher melting point
    - Independent of structural changes
  - Altered meibomian gland structure
    - Controversial
    - May worsen with wear
      - Starts after 1 year of wear
      - Stops after 2-3 years of wear
    - Upper lid glands more affected



© 2026 Dr. Cory J. Lappin

- **Surface Impact on Lens**
  - Reduced tear film stability
    - Reduced
      - Comfort
      - Wear time
      - Visual quality

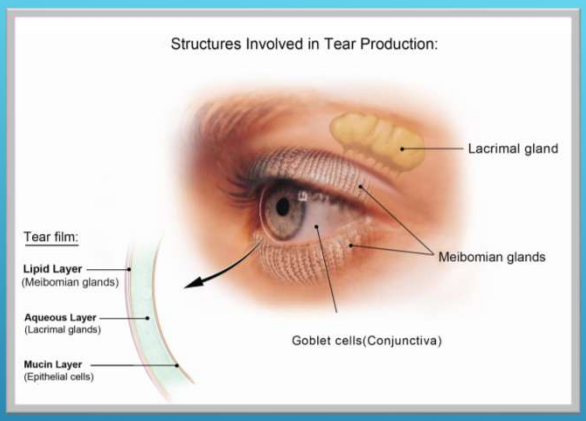


SOFT CONTACTS LENSES: MEIBOMIAN GLANDS

© 2026 Dr. Cory J. Lappin

Function

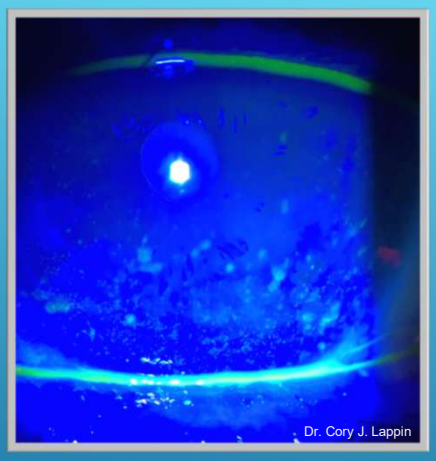
- Produces aqueous component of tears
  - Lubrication and hydration
  - Nourishment
  - Protection



MAIN & ACCESSORY LACRIMAL GLANDS

© 2026 Dr. Cory J. Lappin

- **Lens Impact on Surface**
  - Splits tear film
- **Surface Impact on Lens**
  - Can stabilize cornea and ocular surface
    - Sjogren's Syndrome

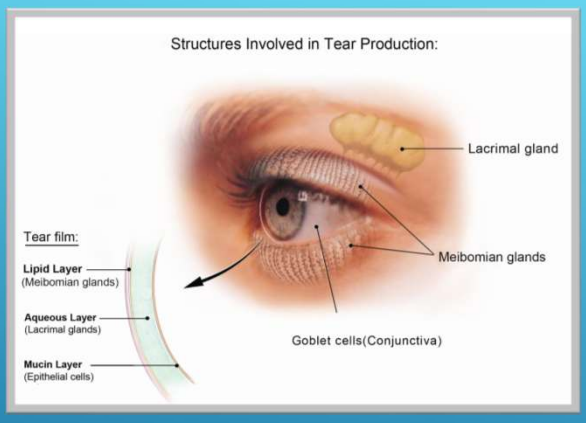


SOFT CONTACTS LENSES: LACRIMAL GLANDS & AQUEOUS TEARS

© 2026 Dr. Cory J. Lappin

Function

- Protection
  - Immune
- Contribute mucin component of tear film
  - Anchors tear film to cornea
  - Lowers surface tension
  - Protection



CONJUNCTIVA & GOBLET CELLS

© 2026 Dr. Cory J. Lappin

- Lens Impact on Surface
  - Hyperemia & Staining
    - Circumlimbal
      - Lens fit, edge interaction
  - Reduced
    - Goblet cell density
    - Mucin production
  - Increased
    - **Lid-parallel Conjunctival Folds (LIPCOF)**
      - Friction

SOFT CONTACTS LENSES: CONJUNCTIVA & GOBLET CELLS

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

- Lens Impact on Surface
  - **Giant Papillary Conjunctivitis (GPC)**
    - Giant papillae (≥1mm)
    - Due to mechanical friction
      - Lens surface dryness, deposits
    - **6-12% of Hydrogel wearers will develop GPC**
    - **Reduced likelihood with daily disposable CLs**

SOFT CONTACTS LENSES: CONJUNCTIVA & GOBLET CELLS

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

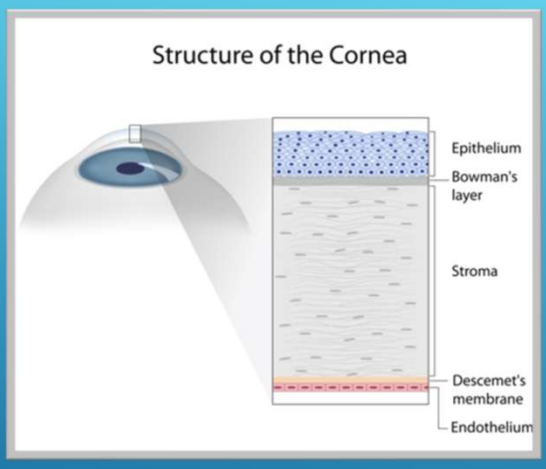
- **Lens Impact on Surface**
  - **Lid Wiper Epitheliopathy (LWE)**
    - Region is adjacent and posterior to the line of Marx
      - In contact with globe
    - Spreads tears across ocular surface
    - Staining of lid wiper due to friction
      - Microtrauma with blinking
      - More common with SCL wear
        - Poorly wettable surface

SOFT CONTACTS LENSES: CONJUNCTIVA & GOBLET CELLS

© 2026 Dr. Cory J. Lappin

Function

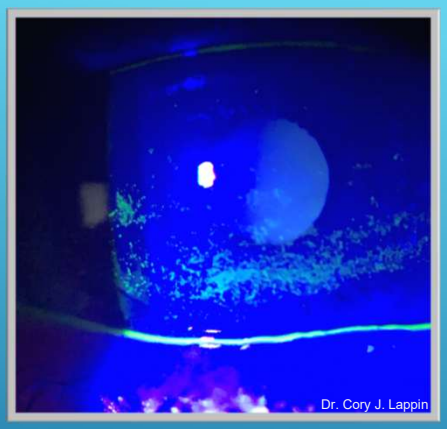
- Protection
- Optical clarity
- Refract light



CORNEA

© 2026 Dr. Cory J. Lappin

- Lens Impact on Surface
  - Staining
    - Present in 54% of SCL wears
      - Less with SiHy wear
    - "Smile" pattern
      - Lens desiccation
    - Limbal staining
      - Excess movement

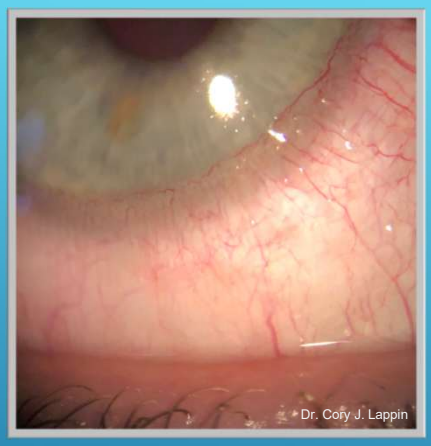


SOFT CONTACTS LENSES: CORNEA

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

- Lens Impact on Surface
  - Hypoxia
    - Reduced epithelial cell metabolism and mitosis
    - Epithelial thinning
    - Premature endothelial cell loss
    - Increased bacterial binding to surface
    - Epithelial microcysts
      - Reverse illumination (appear dark)
      - Degenerated basal epithelial cells
      - Associated with Hydrogels
      - Rare with SiHy wear
    - Vacuoles
      - Fluid between epithelia cells
      - Unreversed illumination
    - Neovascularization
    - Edema

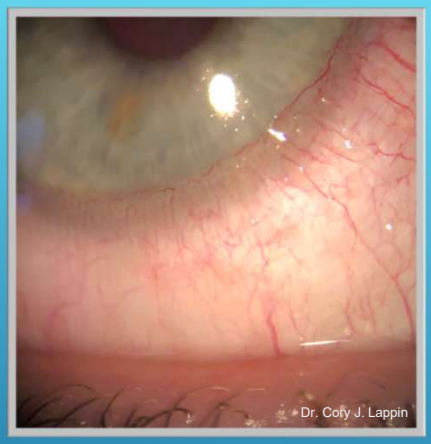


SOFT CONTACTS LENSES: CORNEA

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

- Lens Impact on Surface
  - **Neovascularization**
    - Due to hypoxia
    - Limbal injection
      - Precursor
    - Lipid exudation
    - Scarring
    - Greater risk with overnight lens wear

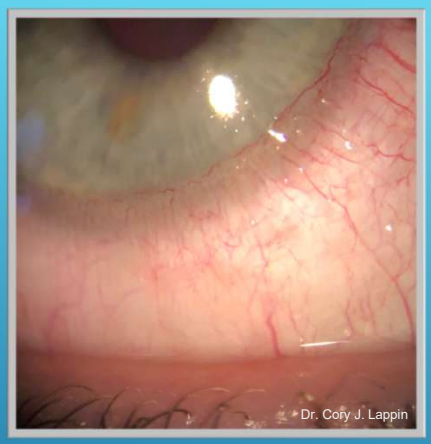


SOFT CONTACTS LENSES: CORNEA

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

- Lens Impact on Surface
  - **Edema**
    - CL wear can reduce oxygen availability
      - Increased anaerobic metabolism by epithelial cells
      - Lactic acid byproduct diffuses into stroma and alters osmotic gradient
        - Stromal edema
          - Striae and/or folds
    - Visual disturbances
      - Glare, halos, rainbows
    - Increased risk with overnight lens wear
    - **Less common with SiHy wear**

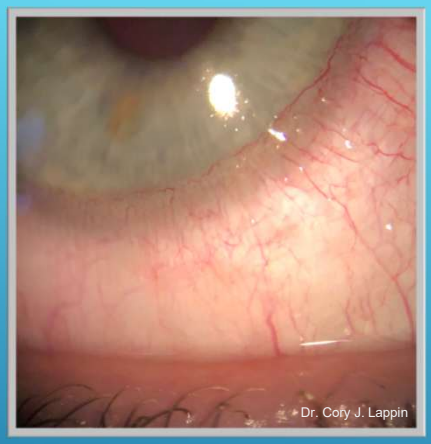


SOFT CONTACTS LENSES: CORNEA

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

- Lens Impact on Surface
  - **Stromal thinning**
    - Reduced keratocyte density
    - Due mechanically induced inflammation
    - **Present in both SiHy and Hydrogel wear**

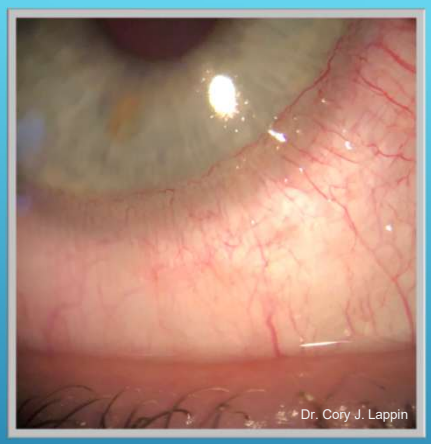


SOFT CONTACTS LENSES: CORNEA

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

- Lens Impact on Surface
  - **Corneal warpage**
    - Increased regular astigmatism
    - Irregular astigmatism
    - **More common in older, low Dk/t Hydrogels**



SOFT CONTACTS LENSES: CORNEA

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

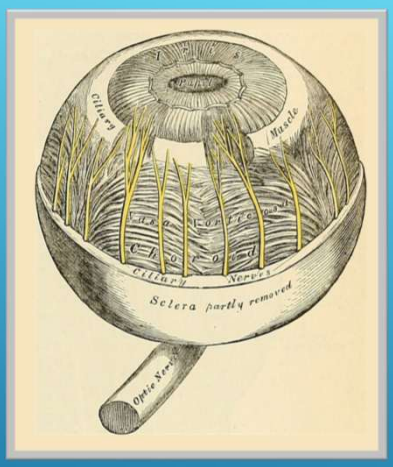
- **Lens Impact on Surface**
  - **Limbal Stem Cell Deficiency (LSCD)**
    - Chronic contact lens-induced:
      - Limbal hypoxia
      - Mechanical trauma to limbus
    - Results in loss of limbal stem cells
      - Impaired wound healing
      - Reduced epithelial cell turnover
      - Corneal conjunctivalization
        - Neovascularization
        - Loss of transparency

SOFT CONTACTS LENSES: CORNEA

© 2026 Dr. Cory J. Lappin

Function

- Cornea densely innervated
  - 7,000 nerve enders per mm^2
- Control
  - Sensation
  - Blinking & Lacrimation
  - Protection
- Corneal surface maintenance
  - Routine epithelial cell turnover
  - Wound healing
  - Nourishment and metabolism



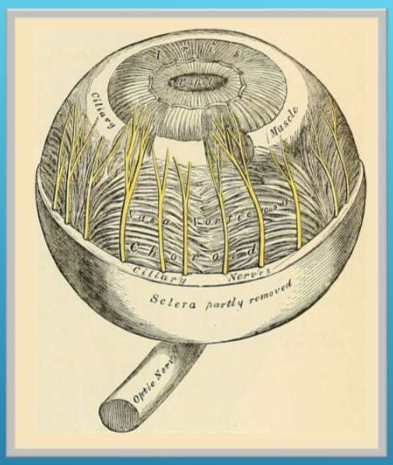
NERVES

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

- **Lens Impact on Surface**
  - **Reduced corneal sensitivity**
    - Adaptation
  - Increased sensitivity at limbus
    - Interaction with lens edge
    - Specialized pressure sensors
  - Reduced palpebral conjunctival sensitivity
  - Reduced lid margin sensitivity
    - Second most sensitive ocular surface structure
  - NGF upregulated in contact lens discomfort
    - Sign of nerve damage

SOFT CONTACTS LENSES: NERVES



© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

- **Lens Impact on Surface**
  - **Neurotrophic Keratitis (NK)**
  - Can be induced by chronic CL-related inflammation
    - Damages corneal nerves resulting in loss of sensation
      - Impaired blinking and lacrimation
      - Reduced epithelial cell turnover
      - Disrupted wound healing

SOFT CONTACTS LENSES: NERVES

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

SOFT CONTACTS LENSES: NERVES

- **Surface Impact on Lens**
  - **Neuropathic Ocular Pain**
  - Pain derived from nerves rather than external stimulus
    - Peripheral or Central
    - Leads to hypersensitivity of cornea
      - Allodynia
        - Photoallodynia
      - Hyperalgesia
    - Lens wear can improve or exacerbate condition

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

SOFT CONTACTS LENSES: INFLAMMATION

- **Lens Impact on Surface**
  - CLs may be intrinsically inflammatory
    - Subclinical
    - Dendritic cells (DC)
      - pathognomonic for immune response
  - Bulbar Conjunctiva and Lid Margin
    - Transient increase in DC
      - Due to deposits, microbes on case
  - Cornea
    - Transient increase in DC
    - Possible microtrauma
    - **Less pronounced with daily disposables**

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

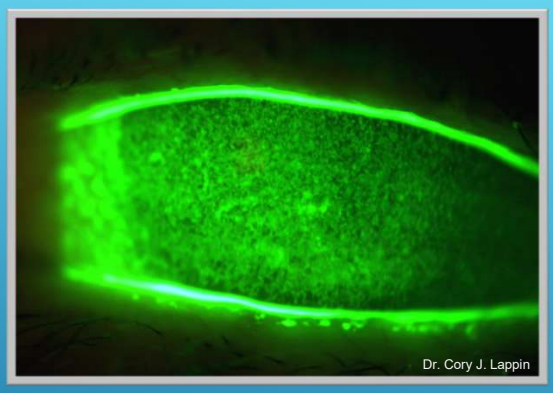
- Surface Impact on Lens
  - Ocular Allergies
  - **40% of contact lens wears experience allergies**
  - Lens discomfort
    - Itching
    - Mucus discharge

SOFT CONTACTS LENSES: ALLERGIES

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

- Impact on Surface
  - **Packing solutions**
    - **Borate**
    - **Phosphate**
    - Both potentially cytotoxic to corneal epithelium
  - **Care solutions**
    - Multipurpose
      - Preservatives as Antimicrobials
        - **PHMB**
        - **Polyquad (BAK-derived)**
      - Potential preservative toxicity



SOFT CONTACTS LENSES: PACKING SOLUTIONS AND CARE SYSTEMS

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

- Lens Impact on Surface
  - **Contact Lens Discomfort (CLD)**
  - **Due to lens itself, NOT external condition**
    - Only occurs when lens is worn, discomfort improves upon removal
  - Mechanism unknown
    - Likely nervous component
  - Can be influenced by
    - Lens material
    - Lens design
    - Wear schedule
    - Care solution

SOFT CONTACTS LENSES: CONTACT LENS DISCOMFORT (CLD)

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

MANAGEMENT

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

Soft Contact Lens and Ocular Surface Management

Lens Selection

Ocular Surface Optimization

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

LENS SELECTION

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

LENS SELECTION: SOFT CONTACT LENS MATERIAL PROPERTIES

- **Dk/t**
  - Oxygen permeability
- **Modulus**
  - Rigidity
- **Lubricity**
  - Friction
- **Wettability**
  - Tear spread & adherence
- **Surface treatments**
  - Surfactants
  - Plasma
  - Wetting Agents
    - Polyvinyl alcohol
    - Hyaluronic acid

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

LENS SELECTION: SOFT CONTACT LENS DESIGN

- **Base curve**
  - Flatter
  - Steeper
- **Diameter**
  - Larger
  - Smaller
- **Lens edge design**
  - Rounded
  - Knife
  - Chisel
- **Thickness**

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

LENS SELECTION: SOFT CONTACT LENS POLYMER TYPES

Silicone Hydrogels
- High oxygen permeability
- Better comfort
- Silicone intrinsically hydrophobic
  - Requires surface treatments
- Lower water content
- Lipid deposition
- "Stiffer" (rigid) modulus

Hydrogels
- Relatively lower oxygen permeability
- More potential issues with comfort
- More hydrophilic
- Higher water content
- Protein deposition
- "Softer" (flexible) modulus

© 2026 Dr. Cory J. Lappin

LENS SELECTION: WEAR SCHEDULES

Daily Disposables
- Deposits negligible
- Increased comfort
- Care solutions not required
- Parameter limitations (relative)
- Convenience
- Higher cost
- Environmental concerns

Monthly & Biweekly Replacement
- More prone to deposit buildup, lens degradation
- Variable comfort with wear duration
- Require care solutions
- Wider parameters (relative)
- Cost effective
- Compliance issues

© 2026 Dr. Cory J. Lappin

CARE SOLUTION SELECTION

Hydrogen Peroxide

- Convenience
  - One step
- Preservative-free
- Better comfort
- Better protection
  - Coverage against Acanthamoeba

Multipurpose Solutions

- Compliance issues
  - Two-step (Rubbing or Rinsing)
- Preservative-containing (Antimicrobial agents)
  - Polyquaternium-1 (PQ-1)
  - Polyhexamethylene biguanide (PHMB)

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

Lens Selection: Takeaways

DAILY DISPOSABLES WHENEVER POSSIBLE

SILICONE HYDROGELS TEND TO PROVIDE BETTER COMFORT

HYDROGEN PEROXIDE SOLUTIONS ARE THE CARE SYSTEMS OF CHOICE

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

OCULAR SURFACE MANAGEMENT

© 2026 Dr. Cory J. Lappin

DRY EYE AND OCULAR SURFACE DISEASE TREATMENTS

- Omega-3 fatty acid supplementation
  - High quality, re-esterified, triglyceride-based supplement with 3:1 EPA to DHA ratio and at least 2 grams of combined EPA and DHA
- Warm compresses
  - May not be ideal for all patients, use with caution in patients with ocular rosacea
- Artificial tears
  - Primarily palliative
  - Recommend preservative-free, lipid-based formulations or gels
- Blink exercises
- Lid hygiene
  - Hypochlorous acid
  - Tea tree oil
  - Okra-based cleansers (Zocular)
- Immunomodulators
  - Lifitegrast (Xiidra)
  - Cyclosporine (Vevye, Cequa, Restasis)
- Neurostimulators
  - Acoltremon (Tryptyr)
  - Varenicline nasal spray (Tyrvaya)
  - iTear100
- Tear film stabilizers
  - Perfluorohexyloctane (Miebo)
- Nocturnal exposure
  - Gels or Ointments
  - Moisture goggles
- Allergies
  - Antihistamine-Mast Cell Stabilizer Combos
    - Olopatadine (Pataday)
    - Alcaftadine (Lastacaft)
  - Preferential Exclusion
    - Ectoin (Allegro)
  - Immunomodulators
    - Cyclosporine (Verkazia)
    - Tacrolimus
  - Ketotifen-eluting Contact Lenses
- Biologics
  - Platelet-rich plasma (PRP)
  - Autologous serum
  - Amniotic membranes
  - Cenegermin-bkbj (Oxervate)
- Other treatments
  - Lotilaner (Xdemvy)
- Advanced procedures
  - Microblepharoexfoliation
    - NuLids
    - BlephEx
  - Ocular surface lavage
    - Rinsada
  - Intense Pulsed Light (IPL)
    - Improves symptoms in contact-lens related DE
    - OptiLight
  - Radiofrequency (RF)
    - OptiPlus
  - Dynamic Muscle Stimulation (DMSt)
    - OptiLift

© 2026 Dr. Cory J. Lappin

CLINICAL PEARLS

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

CLINICAL PEARLS

- A sign of things to come
- Do not overestimate adaptation
- Discuss expectations
- Save wearing time for when most needed
- “If it ain't broke, don't fix it”
- Do not fear spherical equivalent
- The right artificial tear for the job
- Red means stop
- Rinse lenses out of blister pack
- Part-time wearers are excellent candidates for dailies
- When in doubt, go with dailies
- Complications: Strike one…you're still out (and into a new lens)
- Lens selection **AND** ocular surface optimization, **NOT OR**
- Personally try lenses

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

SUMMARY

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

Summary

SOFT CONTACT LENS WEAR PRESENTS A HOMEOSTATIC CHALLENGE

PROPER LENS SELECTION MINIMIZES DISRUPTION TO THE OCULAR SURFACE

OPTIMIZING THE OCULAR SURFACE WILL MAXIMIZE CONTACT LENS COMFORT AND SUCCESS

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

REFERENCES

1. Abusharha AA. Changes in blink rate and ocular symptoms during different reading tasks. Clin Optom (Auckl). 2017;9:133-138. Published 2017 Nov 20. doi:10.2147/OPTO.S142718
2. Allergy-fighting contact lens approved. Review of Optometry. March 2, 2022. Accessed August 6, 2023. https://www.reviewofoptometry.com/article/allergyfighting-contact-lens-approved.
3. Ammer R. Effect of Contact Lens Wear on Tear Film Break up Time (TBUT) among Contact Lens Users. Pakistan Journal of Ophthalmology. 2017; 33:182-186.
4. Arita R, Fukuoka S, Morishige N. Meibomian Gland Dysfunction and Contact Lens Discomfort. Eye Contact Lens. 2017;43(1):17-22. doi:10.1097/ICL.0000000000000351
5. Barnett M. Are you making the most of the newest soft lenses? Review of Optometry. August 15, 2020. Accessed August 6, 2023. https://www.reviewofoptometry.com/article/are-you-making-the-most-of-the-newest-soft-lenses.
6. Bhargava R, Kumar P. Oral omega-3 fatty acid treatment for dry eye in contact lens wearers. Cornea. 2015;34(4):413-420. doi:10.1097/ICO.0000000000000038
7. Billman GE. Homeostasis: The Underappreciated and Far Too Often Ignored Central Organizing Principle of Physiology. Front Physiol. 2020;11:200. Published 2020 Mar 10. doi:10.3389/fphys.2020.00200
8. Bradley CS, Sicks LA, Pucker AD. Common Ophthalmic Preservatives in Soft Contact Lens Care Products: Benefits, Complications, and a Comparison to Non-Preserved Solutions. Clin Optom (Auckl). 2021;13:271-285. Published 2021 Sep 7. doi:10.2147/OPTO.S235679
9. Britannica, T. Editors of Encyclopedia (2022, August 23). Homeostasis. Encyclopedia Britannica. https://www.britannica.com/science/homeostasis. Published: Aug 23, 2022.
10. Cannon WB. Organization for physiological homeostasis. Physiological Reviews. 1929;9:399-431.
11. Chaudhary S, Ghimire D, Basu S, Agrawal V, Jacobs DS, Shanbhag SS. Contact lenses in dry eye disease and associated ocular surface disorders. Indian J Ophthalmol. 2023;71(4):1142-1153. doi:10.4103/IJO.IJO_2778_22
12. Cole J. Choosing the right contact lens modality. Review of Optometry. August 15, 2017. Accessed August 26, 2023. https://www.reviewofoptometry.com/article/ro0817-choosing-the-right-contact-lens-modality.
13. Cope JR, Collier SA, Rao MM, et al. Contact Lens Wearer Demographics and Risk Behaviors for Contact Lens-Related Eye Infections--United States, 2014. MMWR Morb Mortal Wkly Rep. 2015;64(32):865-870. doi:10.15585/mmwr.mm6432a2
14. Coroi MC, Bungau S, Tit M. PRESERVATIVES FROM THE EYE DROPS AND THE OCULAR SURFACE. Rom J Ophthalmol. 2015;59(1):2-5.
15. Craig JP, Nichols KK, Akpek EK, et al. TFOS DEWS II Definition and Classification Report. Ocul Surf. 2017;15(3):276-283. doi:10.1016/j.jtos.2017.05.008
16. Davis R, Eiden B. Contact Lens Spectrum. February 1, 2013. Accessed August 6, 2023. https://www.clspectrum.com/issues/2013/february-2013/problem-solving-soft-toric-contact-lenses.
17. Downie LE, Bandlitz S, Bergmanson JPG, et al. CLEAR - Anatomy and physiology of the anterior eye. Cont Lens Anterior Eye. 2021;44(2):132-156. doi:10.1016/j.clae.2021.02.009
18. Downie LE, Craig JP. Tear film evaluation and management in soft contact lens wear: a systematic approach. Clin Exp Optom. 2017;100(5):438-458. doi:10.1111/cxo.12597
19. Dumbleton K, Caffery B, Dogru M, et al. The TFOS International Workshop on Contact Lens Discomfort: report of the subcommittee on epidemiology. Invest Ophthalmol Vis Sci. 2013;54(11):TFOS20-TFOS36. Published 2013 Oct 18. doi:10.1167/iovs.13-13125
20. Efron N, Morgan PB, Nichols JJ, et al. All soft contact lenses are not created equal. Cont Lens Anterior Eye. 2022;45(2):101515. doi:10.1016/j.clae.2021.101515
21. Fernández-Jimenez E, Diz-Arias E, Peral A. Improving ocular surface comfort in contact lens wearers. Cont Lens Anterior Eye. 2022;45(3):101544. doi:10.1016/j.clae.2021.101544
22. Fjaervoll K, Fjaervoll H, Magno M, et al. Review on the possible pathophysiological mechanisms underlying visual display terminal-associated dry eye disease. Acta Ophthalmol. 2022;100(8):861-877. doi:10.1111/aos.15150
23. Frogozo M. How contact lenses contribute to Dry Eye. Review of Optometry. May 15, 2023. Accessed August 6, 2023. https://www.reviewofoptometry.com/article/how-contact-lenses-contribute-to-dry-eye.
24. Guillon M, Maissa C. Dry eye symptomatology of soft contact lens wearers and nonwearers. Optom Vis Sci. 2005;82(9):829-834. doi:10.1097/01.opx.0000178060.45925.5d
25. Hamedani AG, Gold DR. Eyelid Dysfunction in Neurodegenerative, Neurogenetic, and Neurometabolic Disease. Front Neurol. 2017;8:329. Published 2017 Jul 18. doi:10.3389/fneur.2017.00329
26. Harthan JS. Which factors matter in contact lens selection? Review of Optometry. August 15, 2022. Accessed August 6, 2023. https://www.reviewofoptometry.com/article/which-factors-matter-in-contact-lens-selection.
27. Haworth K, Travis D, Abariga SA, Fuller D, Pucker AD. Silicone hydrogel versus hydrogel soft contact lenses for differences in patient-reported eye comfort and safety. Cochrane Database Syst Rev. 2021;2021(5):CD014791. Published 2021 May 10. doi:10.1002/14651858.CD014791
28. Hirota M, Uozato H, Kawamorita T, Shibata Y, Yamamoto S. Effect of incomplete blinking on tear film stability. Optom Vis Sci. 2013;90(7):650-657. doi:10.1097/OPX.0b013e31829962ec
29. Hydrogen peroxide gets the edge on comfort. Review of Optometry. December 28, 2020. Accessed August 6, 2023. https://www.reviewofoptometry.com/article/hydrogen-peroxide-gets-the-edge-on-comfort.
30. Iskeleli G, Karakoç Y, Aydin O, Yetik H, Uslu H, Kizilkaya M. Comparison of tear-film osmolarity in different types of contact lenses. CLAO J. 2002;28(4):174-176. doi:10.1097/01.ICL.0000024117.46518.A4
31. Inomata T, Nakamura M, Iwagami M, et al. Stratification of Individual Symptoms of Contact Lens-Associated Dry Eye Using the iPhone App DryEyeRhythm: Crowdsourced Cross-Sectional Study. J Med Internet Res. 2020;22(6):e18996. Published 2020 Jun 26. doi:10.2196/18996
32. Jalbert I, Rejab S. Increased numbers of Demodex in contact lens wearers. Optom Vis Sci. 2015;92(6):671-678. doi:10.1097/OPX.0000000000000605

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

REFERENCES

33. Jansen ME, Begley CG, Himebaugh NH, Port NL. Effect of contact lens wear and a near task on tear film break-up. Optom Vis Sci. 2010;87(5):350-357. doi:10.1097/OPX.0b013e3181d951df
34. Jie Y, Sella R, Feng J, Gomez ML, Afshari NA. Evaluation of incomplete blinking as a measurement of dry eye disease. Ocul Surf. 2019;17(3):440-446. doi:10.1016/j.jtos.2019.05.00
35. Jones L, Efron N, Bandamwar K, et al. TFOS Lifestyle: Impact of contact lenses on the ocular surface [published online ahead of print, 2023 May 4]. Ocul Surf. 2023;29:175-219. doi:10.1016/j.jtos.2023.04.010
36. Kaido M, Kawashima M, Ishida R, Tsubota K. Tear Film Dynamics of Soft Contact Lens-Induced Dry Eye. Curr Eye Res. 2020;45(7):782-788. doi:10.1080/02713683.2019.1700530
37. Kojima T. Contact Lens-Associated Dry Eye Disease: Recent Advances Worldwide and in Japan. Invest Ophthalmol Vis Sci. 2018;59(14):DES102-DES108. doi:10.1167/iovs.17-23685
38. Lee J. Proactive contact lens problem-solving. Review of Optometry. March 9, 2004. Accessed August 6, 2023. https://www.reviewofoptometry.com/article/proactive-contact-lens-problem-solving.
39. Lum E, Perera I, Ho A. Osmolality and buffering agents in soft contact lens packaging solutions. Cont Lens Anterior Eye. 2004;27(1):21-26. doi:10.1016/j.clae.2003.11.002
40. Machalińska A, Zakrzewska A, Adamek B, et al. Comparison of Morphological and Functional Meibomian Gland Characteristics Between Daily Contact Lens Wearers and Nonwearers. Cornea. 2015;34(9):1098-1104. doi:10.1097/ICO.0000000000000511
41. Markoulli M, Kolanu S. Contact lens wear and dry eyes: challenges and solutions. Clin Optom (Auckl). 2017;9:41-48. Published 2017 Feb 15. doi:10.2147/OPTO.S111130
42. McDermott GK. A fix-it guide for Toric Lens Fits. Review of Optometry. July 19, 2001. Accessed August 6, 2023. https://www.reviewofoptometry.com/article/a-fix-it-guide-for-toric-lens-fits.
43. McLaughlin R. Contact Lens Spectrum. September 1, 2001. Accessed August 6, 2023. https://www.clspectrum.com/issues/2001/september-2001/rub-vs-no-rub.
44. Molina K, Graham AD, Yeh T, et al. Not All Dry Eye in Contact Lens Wear Is Contact Lens-Induced. Eye Contact Lens. 2020;46(4):214-222. doi:10.1097/ICL.0000000000000661
45. Morgan PB, Murphy PJ, Gifford KL, et al. CLEAR - Effect of contact lens materials and designs on the anatomy and physiology of the eye. Cont Lens Anterior Eye. 2021;44(2):192-219. doi:10.1016/j.clae.2021.02.006
46. Muntz A, Subbaraman LN, Sorbara L, Jones L. Tear exchange and contact lenses: a review. J Optom. 2015;8(1):2-11. doi:10.1016/j.optom.2014.12.001
47. Musgrave CSA, Fang F. Contact Lens Materials: A Materials Science Perspective. Materials (Basel). 2019;12(2):261. Published 2019 Jan 14. doi:10.3390/ma12020261
48. Laxmi Narayana B, Rao P, Bhat S, Vidyalakshmi K. Comparison of the Antimicrobial Efficacy of Various Contact Lens Solutions to Inhibit the Growth of Pseudomonas aeruginosa and Staphylococcus aureus. Int J Microbiol. 2018;2018:5916712. Published 2018 May 31. doi:10.1155/2018/5916712
49. Navascues-Cornago M, Sun T, Read ML, Morgan PB. The short-term effect of contact lens wear on blink characteristics. Cont Lens Anterior Eye. 2022;45(5):101596. doi:10.1016/j.clae.2022.101596
50. Nichols JJ, Chalmers RL, Dumbleton K, et al. The Case for Using Hydrogen Peroxide Contact Lens Care Solutions: A Review. Eye Contact Lens. 2019;45(2):69-82. doi:10.1097/ICL.0000000000000542
51. Nichols JJ, Willcox MD, Bron AJ, et al. The TFOS International Workshop on Contact Lens Discomfort: executive summary. Invest Ophthalmol Vis Sci. 2013;54(11):TFOS7-TFOS13. Published 2013 Oct 18. doi:10.1167/iovs.13-13212
52. Nichols JJ, Willcox MD, Bron AJ, et al. The TFOS International Workshop on Contact Lens Discomfort: executive summary. Invest Ophthalmol Vis Sci. 2013;54(11):TFOS7-TFOS13. Published 2013 Oct 18. doi:10.1167/iovs.13-13212
53. Pisella PJ, Malet F, Lejeune S, et al. Ocular surface changes induced by contact lens wear. Cornea. 2001;20(8):820-825. doi:10.1097/00003226-200111000-00009
54. Rodolfo K. What is Homeostasis? Scientific American. https://www.scientificamerican.com/article/what-is-homeostasis. Published January 3, 2000. Accessed September 11, 2022.Saliman NH, Maldonado-Codina C, Morgan PB. Effect of material and care system combination on subclinical inflammation of the ocular surface in soft contact lens wear. Cont Lens Anterior Eye. 2022;45(4):101489. doi:10.1016/j.clae.2021.101489
55. Saliman NH, Morgan PB, MacDonald AS, Maldonado-Codina C. Subclinical Inflammation of the Ocular Surface in Soft Contact Lens Wear. Cornea. 2020;39(2):146-154. doi:10.1097/ICO.0000000000002192
56. Schorner S. Some facts about SiHy lenses. Review of Optometry. July 15, 2010. Accessed August 6, 2023. https://www.reviewofoptometry.com/article/some-facts-about-sihy-lenses.
57. Sindt CW. What's In your blister pack? Review of Cornea and Contact Lenses. June 18, 2010. Accessed August 6, 2023. https://www.reviewofcontactlenses.com/article/whats-in-your-blister-pack.
58. Sindt CW, Longmuir RA. Contact lens strategies for the patient with dry eye. Ocul Surf. 2007;5(4):294-307. doi:10.1016/s1542-0124(12)70095-2
59. Sridhar MS. Anatomy of cornea and ocular surface. Indian J Ophthalmol. 2018;66(2):190-194. doi:10.4103/ijo.IJO_646_17
60. Srinivasan S. Today's contact lens materials and designs. Review of Optometry. August 15, 2017. Accessed August 6, 2023. https://www.reviewofoptometry.com/article/ro0817-todays-contact-lens-materials-and-designs.
61. Stapleton F, Stretton S, Papas E, Skotnitsky C, Sweeney DF. Silicone hydrogel contact lenses and the ocular surface. Ocul Surf. 2006;4(1):24-43. doi:10.1016/s1542-0124(12)70262-8
62. Surfactant. Contact Lens Update. 2023. Accessed August 6, 2023. https://contactlensupdate.com/2012/03/20/surfactant/.
63. Tahhan N, Naduvilath TJ, Woods C, Papas E. Review of 20 years of soft contact lens wearer ocular physiology data. Cont Lens Anterior Eye. 2022;45(1):101525. doi:10.1016/j.clae.2021.101525
64. Tarkowski W, Moneta-Wielgoś J, Mtocicki D. Demodex sp. as a Potential Cause of the Abandonment of Soft Contact Lenses by Their Existing Users. Biomed Res Int. 2015;2015:259109. doi:10.1155/2015/259109
65. Urgacz A, Mrukwa E, Gawlik R. Adverse events in allergy sufferers wearing contact lenses. Postepy Dermatol Alergol. 2015;32(3):204-209. doi:10.5114/pdia.2015.48071
66. Vidal-Rohr M, Wolffsohn JS, Davies LN, Cerviño A. Effect of contact lens surface properties on comfort, tear stability and ocular physiology. Cont Lens Anterior Eye. 2018;41(1):117-121. doi:10.1016/j.clae.2017.09.009

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

REFERENCES

67. Wagner H. Lifelong contact lens success: Keep allergy and dry eye at bay. Review of Optometry. June 15, 2017. Accessed August 6, 2023. https://www.reviewofoptometry.com/article/lifelong-contact-lens-success-keep-allergy-and-dry-eye-at-bay.
68. Willcox M, Keir N, Maseedupally V, et al. CLEAR - Contact lens wettability, cleaning, disinfection and interactions with tears. Cont Lens Anterior Eye. 2021;44(2):157-191. doi:10.1016/j.clae.2021.02.004
69. Yang L, Pazo EE, Zhang Q, et al. Treatment of contact lens related dry eye with intense pulsed light. Cont Lens Anterior Eye. 2022;45(2):101449. doi:10.1016/j.clae.2021.101449
70. Yeung KK. Dissecting the soft contact lens. Review of Optometry. August 15, 2018. Accessed August 6, 2023. https://www.reviewofoptometry.com/article/dissecting-the-soft-contact-lens.
71. York M, Ong J, Robbins JC. Variation in blink rate associated with contact lens wear and task difficulty. Am J Optom Arch Am Acad Optom. 1971;48(6):461-467. doi:10.1097/00006324-197106000-00001
72. Zhu H, Bandara MB, Vijay AK, Masoudi S, Wu D, Willcox MD. Importance of rub and rinse in use of multipurpose contact lens solution. Optom Vis Sci. 2011;88(8):967-972. doi:10.1097/OPX.0b013e31821bf976
73. 3 mistakes you're making with your contact lenses. SELF. November 2, 2011. Accessed August 26, 2023. https://www.self.com/story/3-mistakes-youre-making-with-y.
74. Nascari D, Sved A. Homeostasis success or failure. Wikimedia Commons. CC BY-SA 4.0. https://commons.wikimedia.org/wiki/File:Homeostasis_success_or_failure.png. Published August 26, 2019. Accessed September 3, 2021.
75. Structures Involved in Tear Production. https://medialibrary.nei.nih.gov/sites/default/files/media-images/NEI-medialibrary-3842733.jpg. Accessed September 3, 2021.
76. Sem J. Fish oil capsules. CC BY 2.0, www.semtrio.com. Published September 12, 2018. Accessed December 18, 2021.
77. johnny_automatic. Johnny-automatic-scales-of-justice. https://openclipart.org/detail/26849/scales-of-justice. Wikimedia Commons. CC0, https://commons.wikimedia.org/w/index.php?curid=46844394. Published February 7, 2016. Accessed September 3, 2021.

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO

THANK YOU!

INSTAGRAM:
@CORY.LAPPIN
@DRYEYECENTEROFOHIO

© 2026 Dr. Cory J. Lappin

THE DRY EYE CENTER OF OHIO