What's New & Sexy in Contacts?

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Financial Disclosures

Over the past three years, CORE has received research funding and/or honoraria from the following 18 companies & 8 funding agencies:

- Alcon
- Allied Innovations
- Azura Ophthalmics
- Bausch + Lomb Corp
- CooperVision
- Essilor
- Hoya
- i-Med Pharma
- Johnson & Johnson Vision
- Menicon
- Novartis
- Ophtecs
- Oté Pharma
- Santen
- SightGlass
- SightSage
- Topcon
- Visioneering Tech Inc

NSERC CRSNG | CIHR IRSC | Mitacs | The Canadian Association of Optometrists | HORIZON 2020 | INNOVATION.CA | Innovation and Technology Commission | AMERICAN ACADEMY of OPTOMETRY

2

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- **Founder/Owner, Better1 Better2.com**
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Financial Disclosures

Alcon
Johnson & Johnson
Coopervision

3

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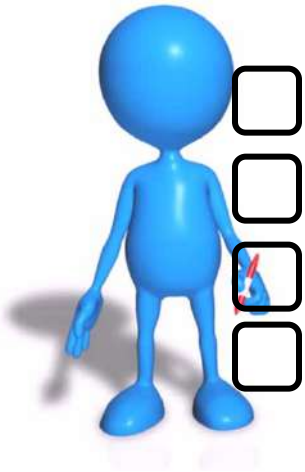
Financial Disclosures

Boston Sight
Coopervision
Eaglet
Euclid
Paragon
Pentavision
Precision Technology
Vistakon
Wave

4

Lecture Outline….



1. Updates on SiHy materials & DD options
2. Updates on MM options
3. Updates on specialty lenses
4. Updates on future uses of CL

5

Updates on SiHy Options

6

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Silicone Hydrogels

Silicone hydrogel lenses are crucial for providing optimal patient care in today's rapidly evolving optometric landscape.

Oxygen Permeability
- Breakthrough in oxygen permeability reducing hypoxia-related complications

Adaptable for Enhancement
- Additives for improved dK and surface treatments that reduce bacterial adhesion

Versatility
- Wide range of available parameters, make lenses suitable for a diverse patient population.

Future Trends
- Future potential including drug delivery and smart lens technology.

1. Stapleton F, Keay L, Edwards K, Naduvilath T. "The epidemiology of contact lens related infiltrates." Optom Vis Sci. 2007;84(4):257-272.
2. Dumbleton K, Woods CA, Jones LW, Fonn D. "The impact of contemporary contact lenses on contact lens discontinuation." Eye Contact Lens. 2013;39(1):93-99.
3. Efron N, Morgan PB, Katsara SS. "Validation of grading scales for contact lens complications." Ophthalmic Physiol Opt. 2001;21(1):17-29.

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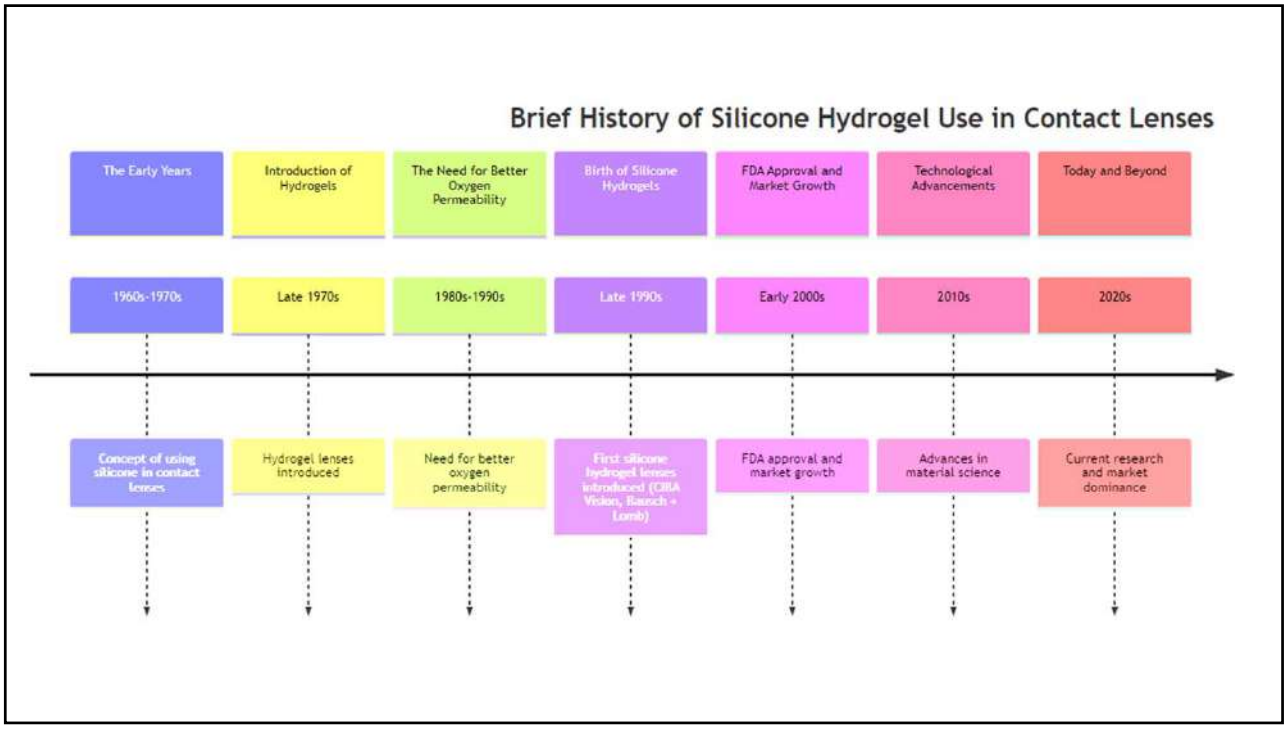

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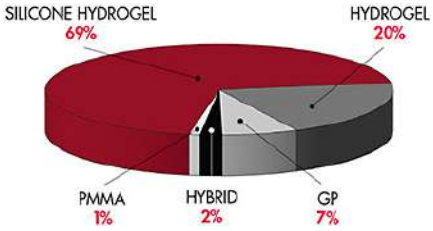
Silicone Hydrogel Lenses: The New Standard

Widespread Adoption: Silicone hydrogel lenses have become the standard in contact lens practice due to their high oxygen permeability, ability to adapt, and versatility.

Clinical Benefits: Reduced rates of hypoxia-related complications, suitability for extended wear, and a wide range of available parameters make them a go-to choice.



Contact Lens Spectrum. (2022, January). Contact Lenses 2021. Contact Lens Spectrum. https://www.clspectrum.com/issues/2022/january-2022/contact-lenses-2021

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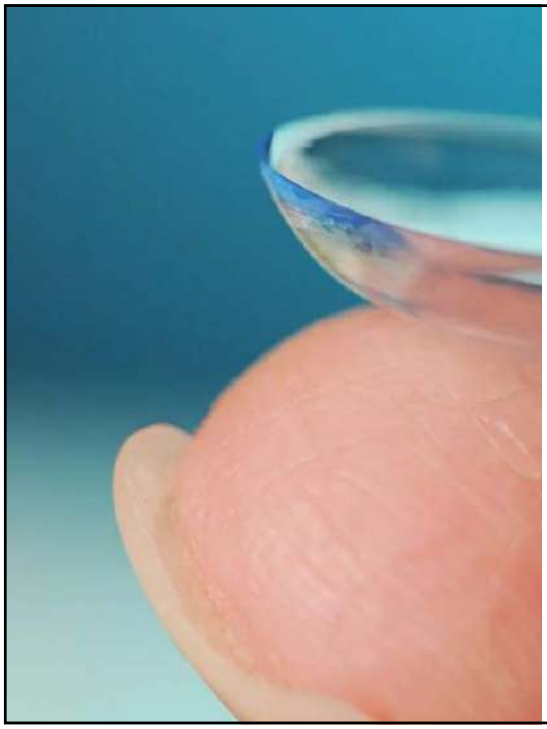

Updates on SiHy Materials

- Moisture-Retaining Technologies
- Surface Treatments
- Oxygen Permeability
- Incorporation of UV Blockers
- Completely New Designs

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Moisture Retaining Technologies

Goal: Improve the wearing experience by maintaining hydration, reducing dryness and enhancing comfort

Hyaluronic Acid (HA)

Hyaluronic acid is a naturally occurring biopolymer found in the human body, known for its exceptional moisture retention properties.Can hold many times its weight in water, making it an ideal hydrating agent for contact lenses. When incorporated into silicone hydrogel lenses, HA helps to create a moisture cushion on the lens surface, improving comfort and reducing symptoms of dryness.

.

PVP (Polyvinylpyrrolidone)

Polyvinylpyrrolidone (PVP) is another hydrophilic (water-attracting) polymer used in the manufacturing of contact lenses to improve moisture retention. PVP forms a hydrogel that binds water molecules, keeping the lens surface smooth and hydrated.

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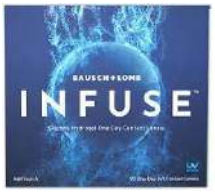
Surface Treatments

- **Aquaform® Technology**.
- **Menisilk™ and Nanogloss™**
- **MoistureSeal™ Technology**
- **SmartShield™ Technology**
- **Smart Silicone™ Technology**
- **WetLoc™ Technology**
- **Hydraglyde® Moisture Matrix**
- **Lacreon® Technology**
- **HydraMax™ Technology**
- **AquaGen™ Technology**
- **ProBalance® Technology**
- **Celligent® Technology**
- **TearStable™ Technology**

The contact lens industry leverages advanced technologies focused on enhancing hydration and comfort by ensuring a smooth lens surface for wearers. The goal is to provide contact lens users with a wearing experience that maximizes lens performance throughout the day.



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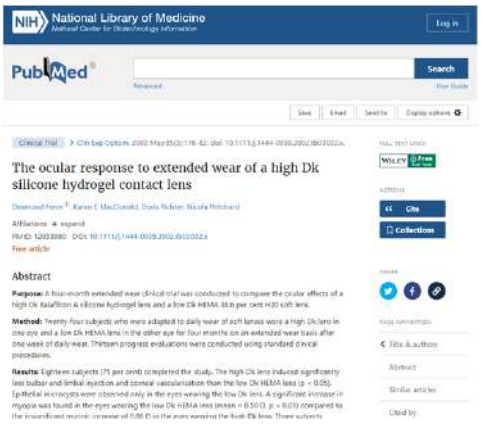
Oxygen Permeability

Higher Dk values allow more oxygen to pass through the lens, reducing the risk of hypoxia and related complications like corneal neovascularization and microbial keratitis.

Material Innovations and Manufacturing Techniques

Example: One manufacturer is maximizing oxygen permeability while using less silicone. This allows for more space within the lens material for built-in channels providing higher oxygen transmission

Example: One manufacturer has developed a water gradient technology that increases the water content towards the outer surface of the lens, providing a soft surface for comfort while maintaining a core design that optimizes oxygen permeability.



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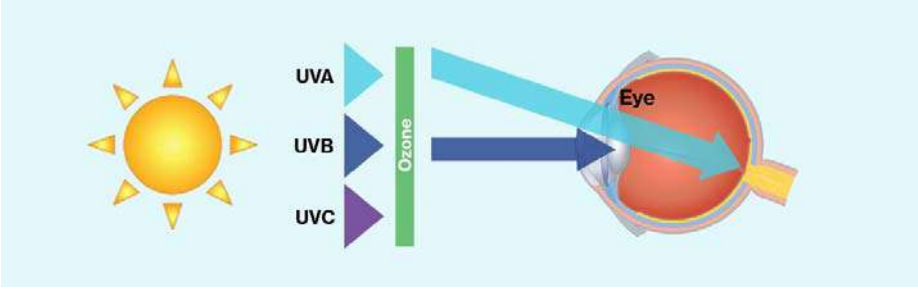
Incorporation of UV Blockers

- UV-blocking contact lenses are designed with materials that can absorb or block a portion of the UV radiation entering the eye.
- These lenses typically target UV-A and UV-B rays, both of which can contribute to eye conditions such as cataracts and photokeratitis.



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New Designs: Smart Release Systems

- Lenses are designed to gradually release moisturizing agents over time, ensuring that the lens surface remains hydrated throughout the day.

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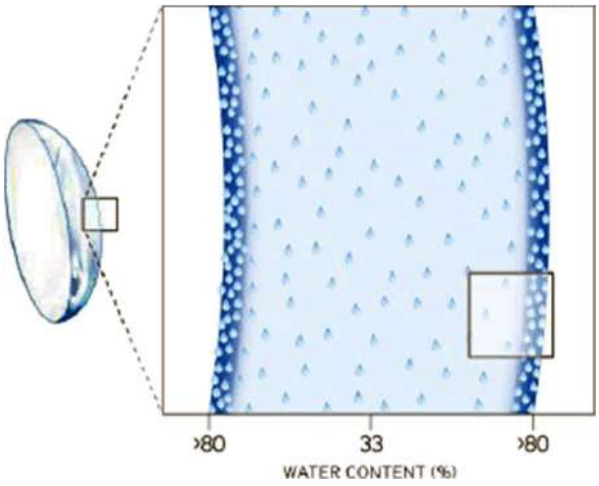
New Design: Water Gradient Lenses

- Lens material itself is engineered to increase water content towards the outer surface, reaching nearly 100% at the very exterior.



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Updates on DD Options

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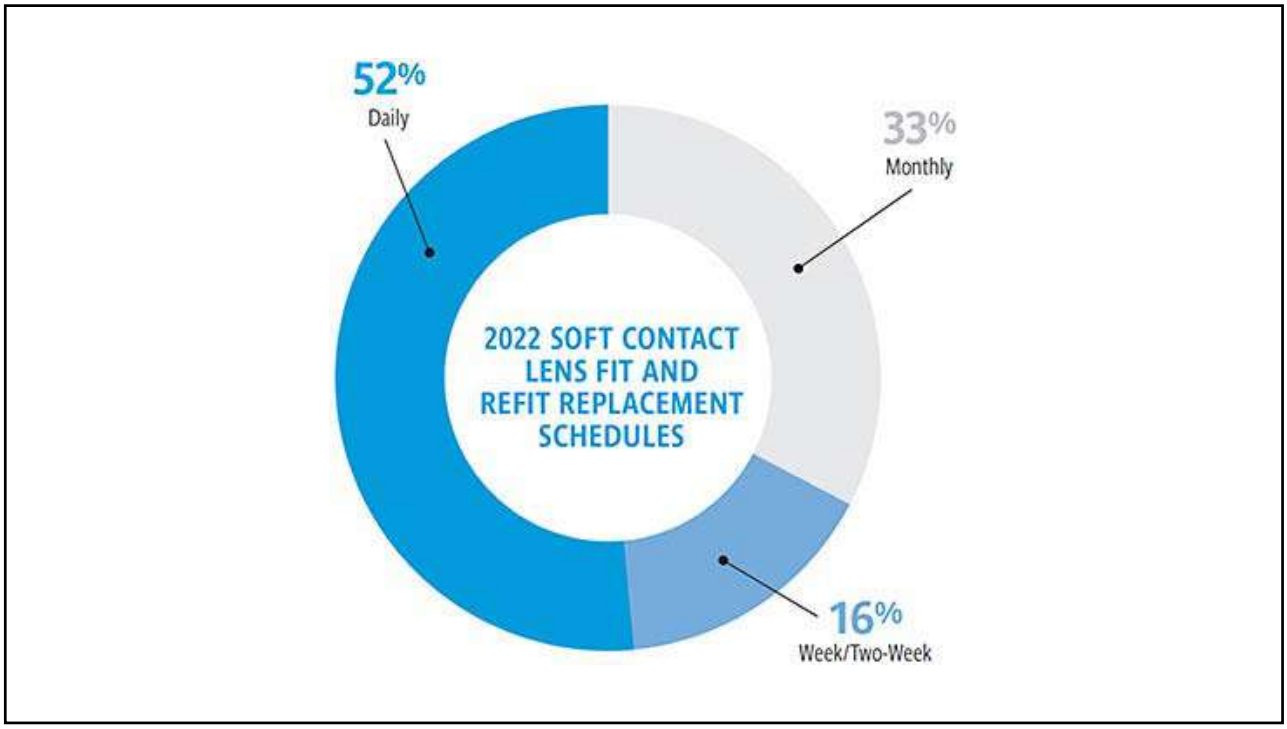

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What's New in DD Lenses?

- **Material Advancements**
- **Enhanced Moisture Technologies**
- **Design Innovations**
- **UV Protection**
- **Multifocal and Toric Options**
- **Packaging Innovations**
- **Value-Added Services**
- **Safety Profile**
- **Performance Profile**

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Design Innovations

- Vision
  - o High-Definition Optics
  - o Aspheric Lens Designs
- Parameters
  - o Optimized Base Curve Selections
- Comfort
  - o Thin Edge Designs

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Multifocal & Toric Options

- Expanding the range of prescriptions available in daily disposables, including options for astigmatism and presbyopia
- Allows more people to enjoy the convenience and health benefits of daily disposables.

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Packaging Innovations

- Manufacturers are also focusing on improving the packaging of daily disposable lenses to make them more user-friendly and environmentally sustainable.
- Efforts include reducing plastic use, simplifying the process of lens removal from the packaging, and ensuring that the packaging is recyclable.

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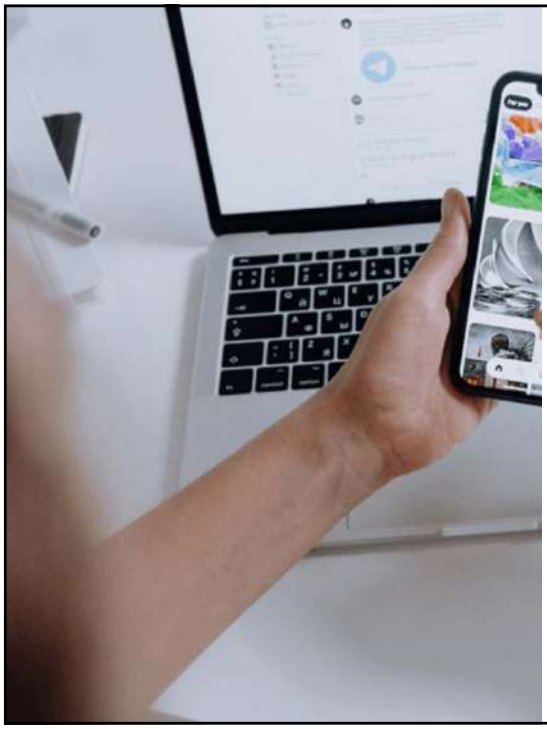

Value Added Services

- Some companies are offering added benefits, such as subscription services, easy online ordering and home delivery, and flexible return policies to enhance the purchasing and wearing experience.

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Safety Profile

As healthcare providers, our primary concern is the safety and well-being of our patients.

The latest updates in daily disposables are geared towards minimizing risks.

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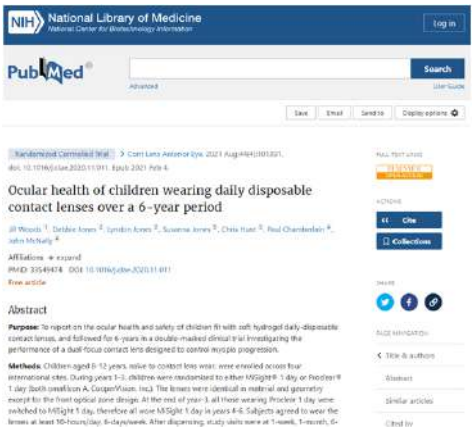
Safety and Risk Reduction

2021 study found minimal impact on ocular physiology in a pediatric population after six years of daily disposable wear.

- **Safety**: High retention rate of 68% over six years with only one lens-related adverse event. No cases of microbial keratitis observed.
- **Discontinuations**: Most dropouts occurred in the first month due to lens fit or handling issues. Overall, discontinuation rates were lower compared to adult studies.
- **Adverse Events**: Majority were minor and manageable, such as 'dryness' and 'lens stinging on insertion'.
- **Ocular Health**: No significant hypoxic or physiological changes observed in biomicroscopy assessments.
- **Clinical Implications**: Results support the safety and efficacy of daily disposable lenses for myopia control in children, encouraging eyecare practitioners to consider this option.



Woods J, Jones D, Jones L, et al. Ocular health of children wearing daily disposable contact lenses over a 6-year period. Cont Lens Anterior Eye. 2021 Aug;44:101391.

25

Safety and Risk Reduction

A recent study concluded that not only are daily disposable contact lenses a safe and effective form of vision correction compared to spectacle correction, they also resulted in improved quality of life measures

- 110 subjects (13 to 19 years old)
- After 6 months of wearing contact lenses, teenagers had a more positive attitude toward comfort, vision, and safety with contact lenses.
- No serious adverse events were reported during the study.

Plowright AJ, Maldonado-Codina C, Howarth GF, Kern J, Morgan PB. Daily disposable contact lenses versus spectacles in teenagers. Optom Vis Sci. 2015 Jan;92:44-52.

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Performance Profile

Daily

Weekly

Monthly

27

Contrast with Other Modalities

Microbial Keratitis

- **Daily Disposable Lenses**: Studies have shown that daily disposable lenses are associated with less severe forms of microbial keratitis[1]. The risk of infection with environmental organisms is significantly lower in daily disposable lenses compared to other modalities[2].
- **Weekly and Monthly Lenses**: These lenses have been associated with a higher risk of microbial keratitis, especially when not properly disinfected[3].

1. Stapleton & Carnt: Contact lens-related microbial keratitis: how have epidemiology and genetics helped us with pathogenesis and prophylaxis. Eye (Lond) 2012; 26;2: 185-93.
2. Stapleton et al.: Risk factors and causative organisms in microbial keratitis in daily disposable contact lens wear. PLoS One 2017; 12;8: e0181343.
3. Radford et al. Disposable contact lens use as a risk factor for microbial keratitis. Br J Ophthalmol 1998; 82;11: 1272-5.

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Contrast with Other Modalities

Comfort

- **Daily Disposable Lenses**: Generally offer better comfort. Specific lenses have been cited for all-day comfort and longer wearing time[1].
- **Weekly and Monthly Lenses**: Comfort can vary and may require more frequent lens care to maintain comfort levels[2].

1. Schulze MM, Fadel D, Luensmann D, Ng A, Guthrie S, Woods J, Jones L. Evaluating the Performance of Verofilcon A Daily Disposable Contact Lenses in a Group of Heavy Digital Device Users. *Clin Ophthalmol.* 2023;17:3165-3175
2. Fahmy M, Long B, Giles T, Wang CH. Comfort-enhanced daily disposable contact lens reduces symptoms among weekly/monthly wear patients. Eye Contact Lens. 2010 Jul;36(4):215-9.

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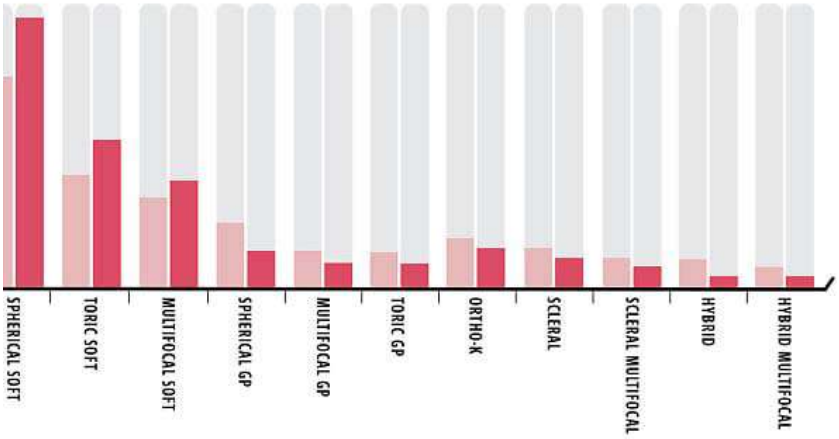
Industry Trends



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Industry Trends: Pricing

- Contact lens manufacturers started pushing 1% to 2% price increases across a number of product lines in 2022.
- In 2023 these price increases seemed to accelerate a bit, closer to 2% to 3% on average.
- With inflationary pressures on wages remaining steady in 2023, many of these increases were pushed through by the big four providers to help offset higher manufacturing costs.

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Industry Trends

- Despite another year of concerns about inflation and other uncertainties, the soft contact lens market remained resilient in 2023 and delivered another year of above-normal growth.

9% Growth

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Industry Trends: Pricing

- The other factor that drove contact lens average prices higher in 2023 was new product launches, (torics, multifocals, and multifocal torics).
- Many of these being offered in daily disposable franchises
- The benefits of stepping wearers up from non-dailies to dailies remained sizable in 2023, and likely had more impact than the industry had seen in many years.

Daily Disposables
~60% (2023) was ~35% (2009)

Toric Lenses
~25% (2023) was 15% (2009)

Multifocal Lenses
~10% (2023) was 5% (2009)

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Risks Associated with Market Trends?

- Extend the use of their daily lenses to two or three days instead of sticking to single-day use
- Trading back down in the short run economic conditions worsen

Survey of our colleagues

59% believe that they will see an increase

35% believe that it will stay the same

5% indicate that it will be decreasing further

"What is the outlook on your contact lens practice n 2024?"

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Daily Disposables: The New Standard

- Health
- Comfort
- Convenience
- Compliance
- Flexibility
- Value
- Parameter Expansion
- Materials
- Practice Management

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Updates on Myopia Management Options

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Lens Options for Myopia Control

1. Soft
   - Daily
   - Monthly
   - Custom
2. Orthokeratology
3. Hybrid & Scleral

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Contact Lens Safety is Sexy…

The privilege for ECPs to prescribe contact lenses could be threatened by unsafe use…

DO NOT IGNORE A RED EYE!

PREVENT, FOLLOW-UP, TREAT!

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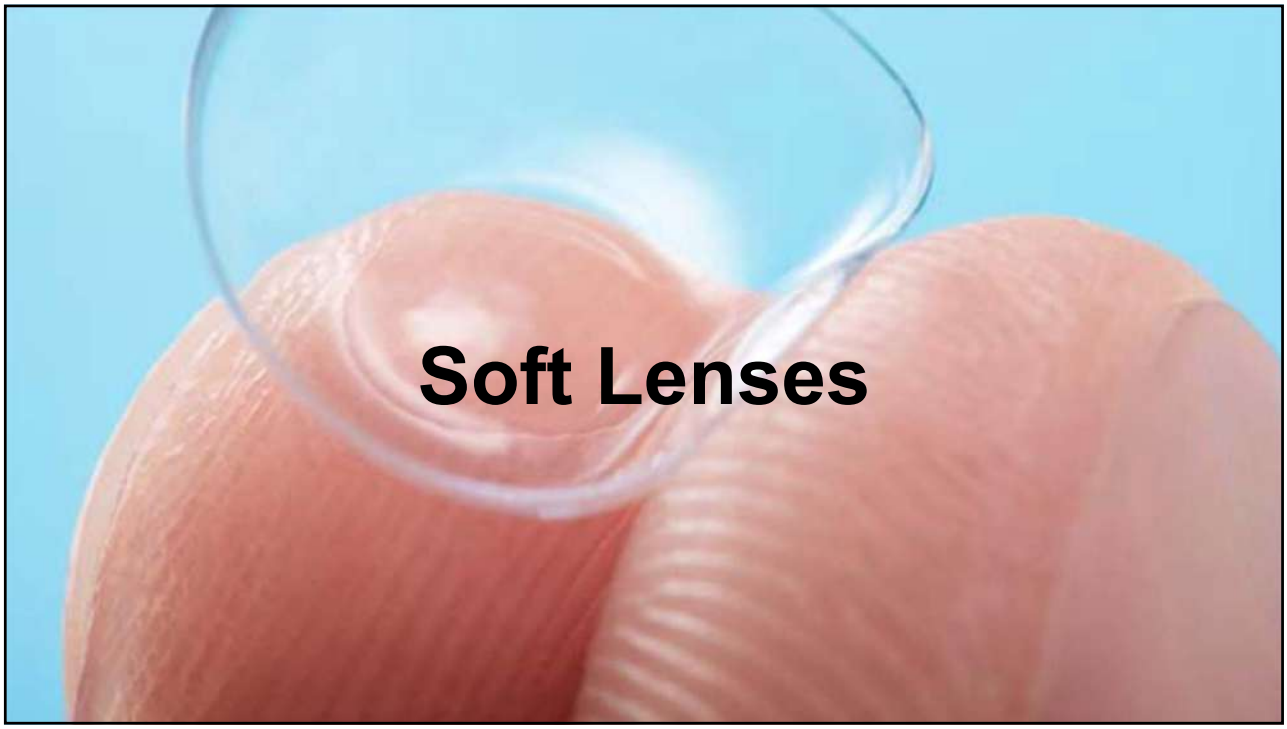

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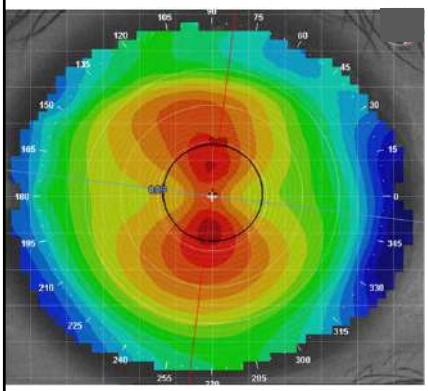
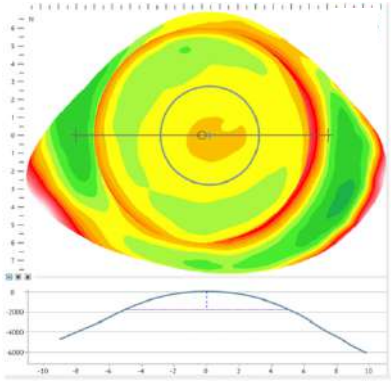
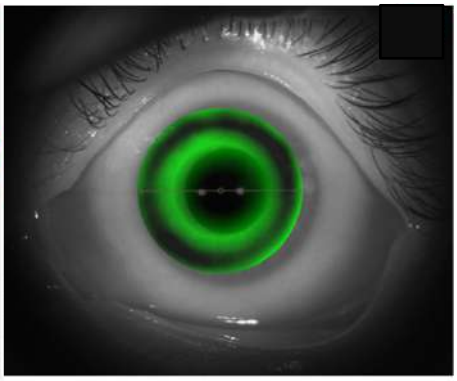
Orthokeratology: Digital/Empirical World







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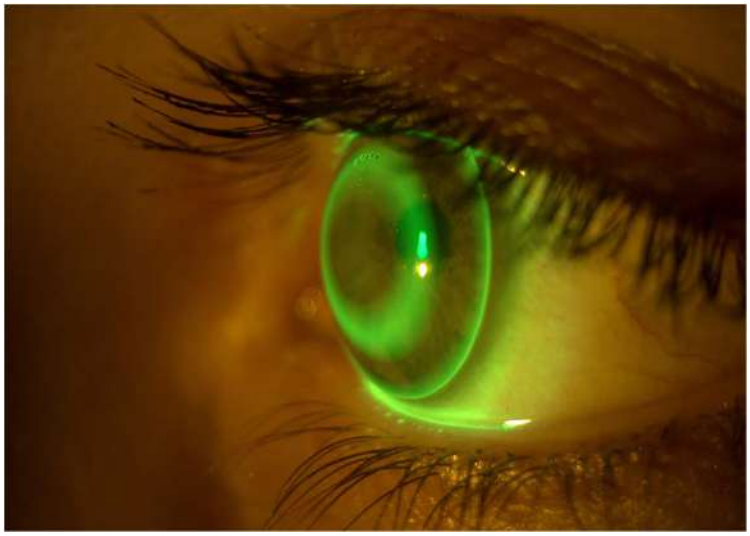
Controversy: Does a Smaller Treatment Zone Improve Orthokeratology for Myopia Control?



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Hybrid/Scleral

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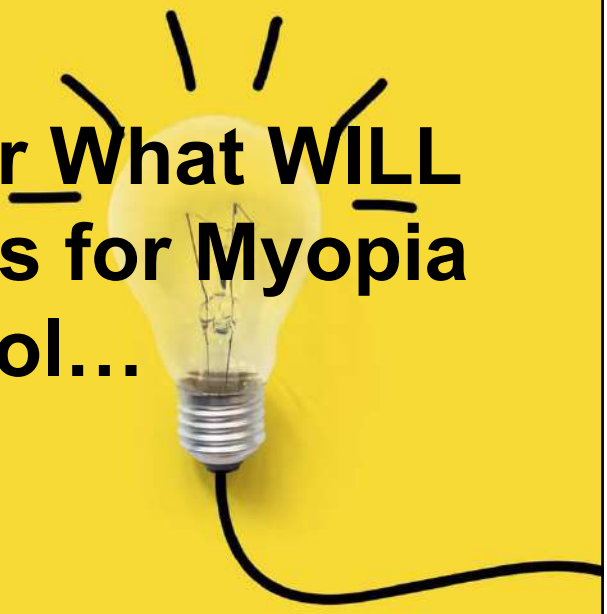
Predictions for What WILL BE Sexy in CLs for Myopia Control…



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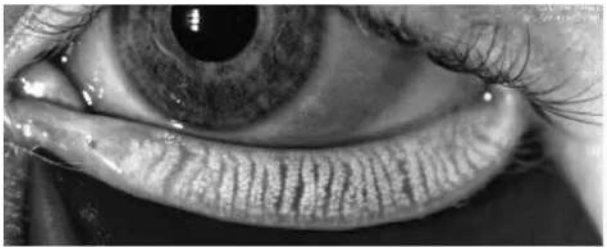
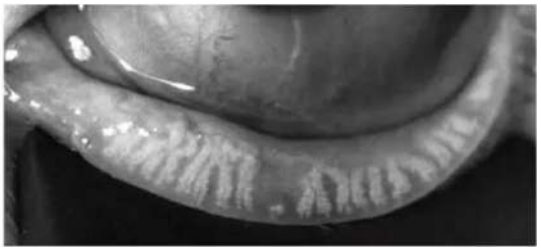
Meibomian Gland Loss in CL Patients... Including Kids!





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Updates on Specialty Lenses

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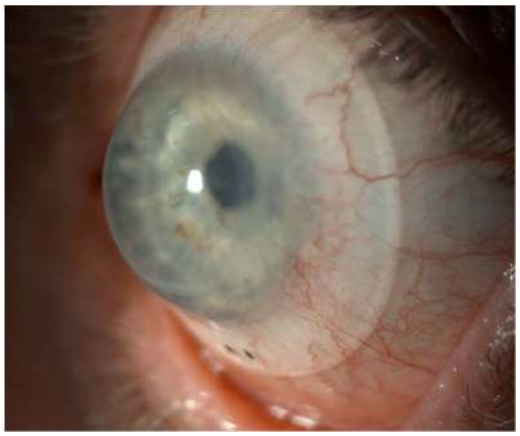

The Final Destination is Extraordinary

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Infant Aphakia Key Clinical Summary (2024)

Corneal GP	Common Infant Soft	Custom Infant Soft
Requires more experienced fitter	Relatively easier to fit, well tolerated	
Daily wear	Some extended wear	
Highest precision in power	+7D to +35D; 3D steps over 20D	More flexibility with power
Can correct some corneal cyl	Usually spherical correction	
Easy to get	Shortage/Backorder	Easy to get

- Fitters have faced supply chain shortage in 2023-2024
- Refractive Target: aim for 2.5-3D minus over-refraction
  - ie: over plus to favor near & intermediate world during visual pathway development
- Expect changes to power (reduction of hyperopia) q3-6m
- Around age 2yo may use a lined bifocal or progressive

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Advancements in Scleral Lens Fitting

- Troubleshooting scleral lenses has become more complex as research expands
- The standard of care and technology available today are different than the past
- Manufacturers have improved materials and lathing techniques, providing greater opportunity to create advanced lens customizations

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Advancements in Scleral Contact Lens Fitting Technology

- Tools to consider:
  - Topography, Tomography, Anterior Segment OCT, Scleral Profilometry, Wavefront Aberrometry
  - Impression-Based Lens Designs
  - Artificial Intelligence
  - Multifocals, Fenestrations
  - Blood Biologics

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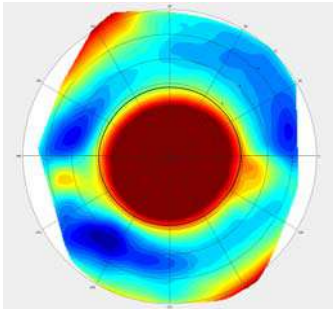
Scanned or Imprinted Lenses:

1. Optimize comfort on irregular scleral shape
2. Efficiently achieve stability of a scleral lens
3. May reduce chair time for a fit
4. Gets us to HOA OPTIC PLACEMENT and other customizations, faster



*Data driven lens design applies to Spherical, Toric, Quad Specific, and Asymmetrical Free-form lens design!

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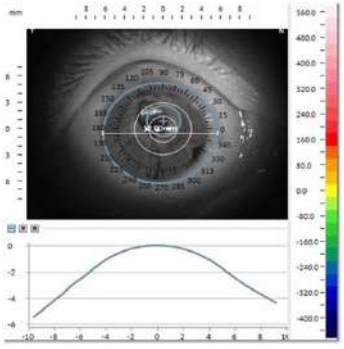
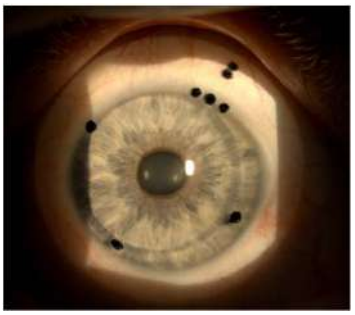
Decentered MF, Wavefront EDOF Optics, HOA





Wavefront guided/HOA lenses require clear corneas and stable lenses

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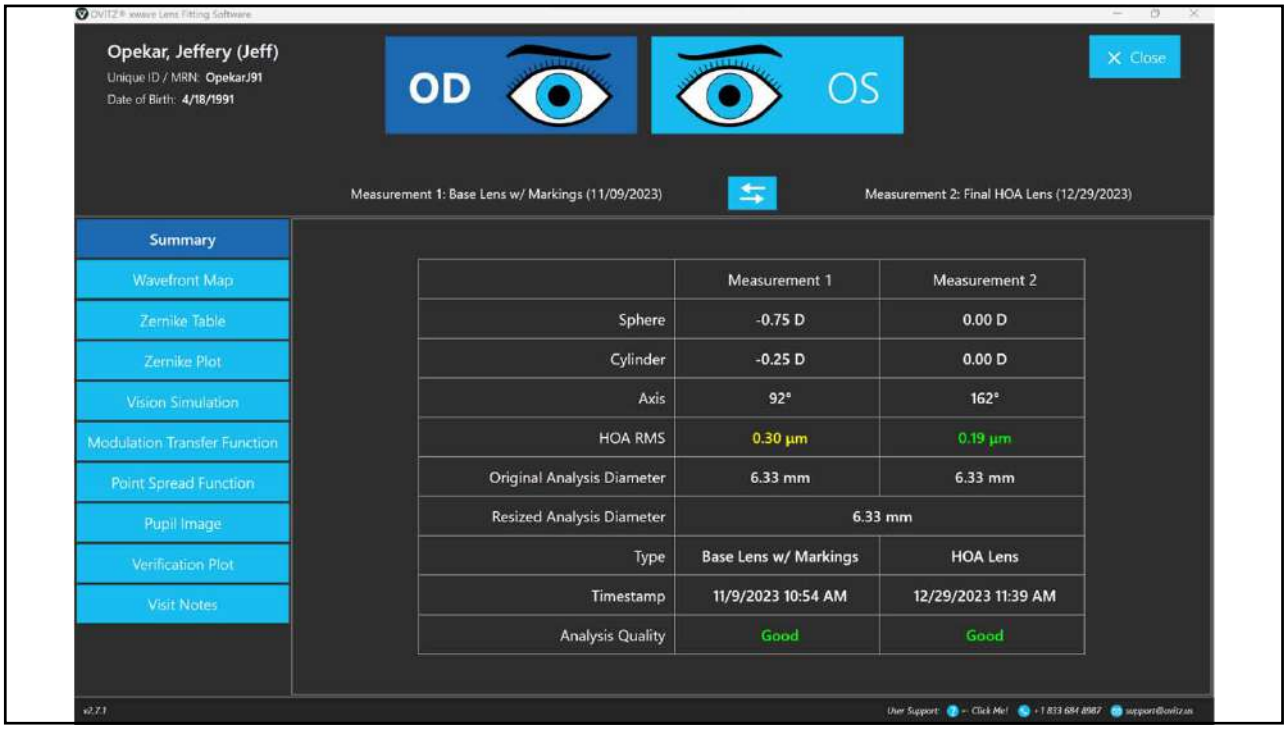
Opekar, Jeffery (Jeff)
Unique ID / MRN: OpekarJ91
Date of Birth: 4/18/1991
OD
OS
Close
Measurement 1: Base Lens w/ Markings (11/09/2023)
Measurement 2: Final HOA Lens (12/29/2023)
Summary
Wavefront Map
Zernike Table
Zernike Plot
Vision Simulation
Modulation Transfer Function
Point Spread Function
Pupil Image
Verification Plot
Visit Notes
Measurement 1
Measurement 2
Sphere
-0.75 D
0.00 D
Cylinder
-0.25 D
0.00 D
Axis
92°
162°
HOA RMS
0.30 µm
0.19 µm
Original Analysis Diameter
6.33 mm
6.33 mm
Resized Analysis Diameter
6.33 mm
Type
Base Lens w/ Markings
HOA Lens
Timestamp
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12/29/2023 11:39 AM
Analysis Quality
Good
Good

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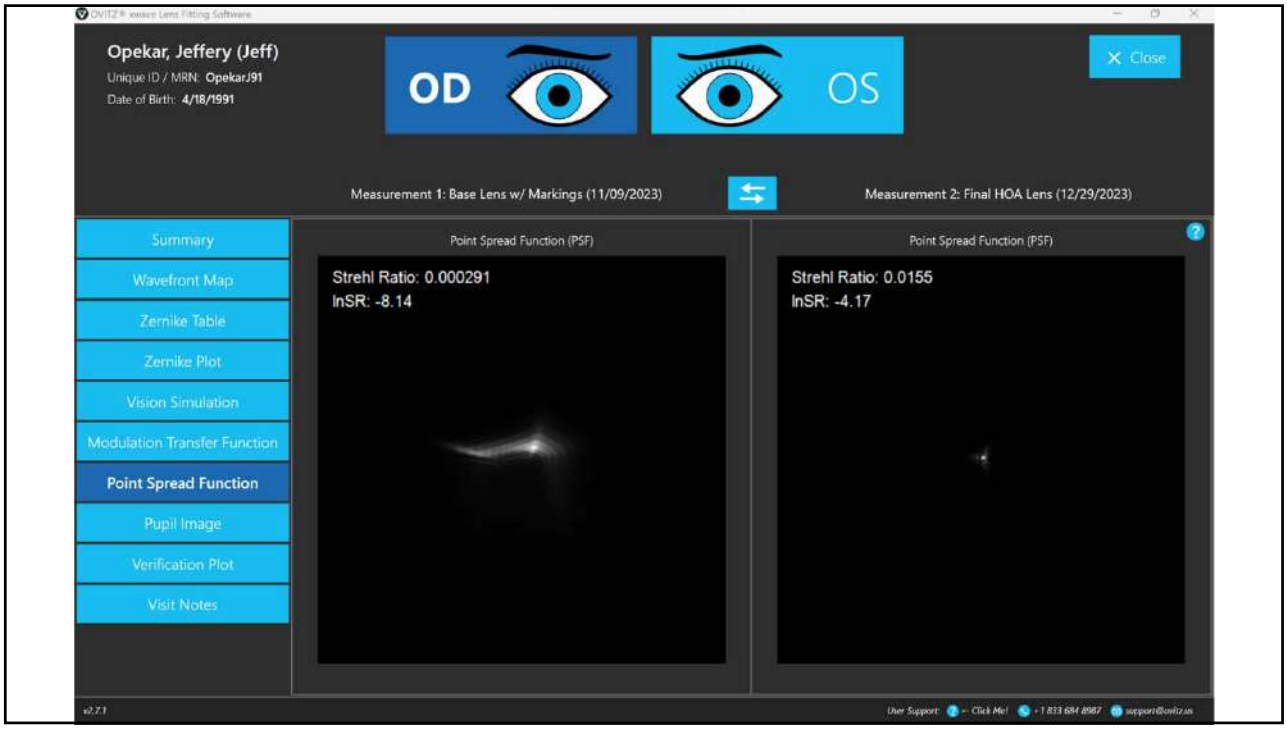
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Modulation Transfer Function
Point Spread Function
Pupil Image
Verification Plot
Visit Notes
Point Spread Function (PSF)
Strehl Ratio: 0.000291
lnSR: -8.14
Point Spread Function (PSF)
Strehl Ratio: 0.0155
lnSR: -4.17

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AI & Scleral Lenses

- Virtual Assistants could theoretically help with your fit in real-time (just like chatbots online!)
- AI could help better determine first lens fit success (vault necessary, most likely diameter to succeed, etc)
  - Could also help consultants/doctors to more accurately recommend fit changes based on anterior segment photograph
  - E.g. send in a photo & AI could help a manufacturer make recommendations for how many microns to flatten/steepen an edge based on the photo
  - And it's not just sclerals…
- Fan, Y., et al. (2022) Machine learning algorithm improves accuracy of ortho-K lens fitting in vision shaping treatment. Contact Lens & Anterior Eye; 45(3).

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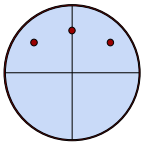
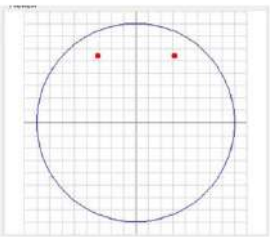
Fenestrations/Channels Are The New Black

1. Edema: Improved oxygen delivery with combination of mid-peripheral fenestrations and channels ?
2. Lens Suction: Decreased lens suction of scleral lens with deep sagittal height and non-dexterous patient using peripheral fenestrations ✅





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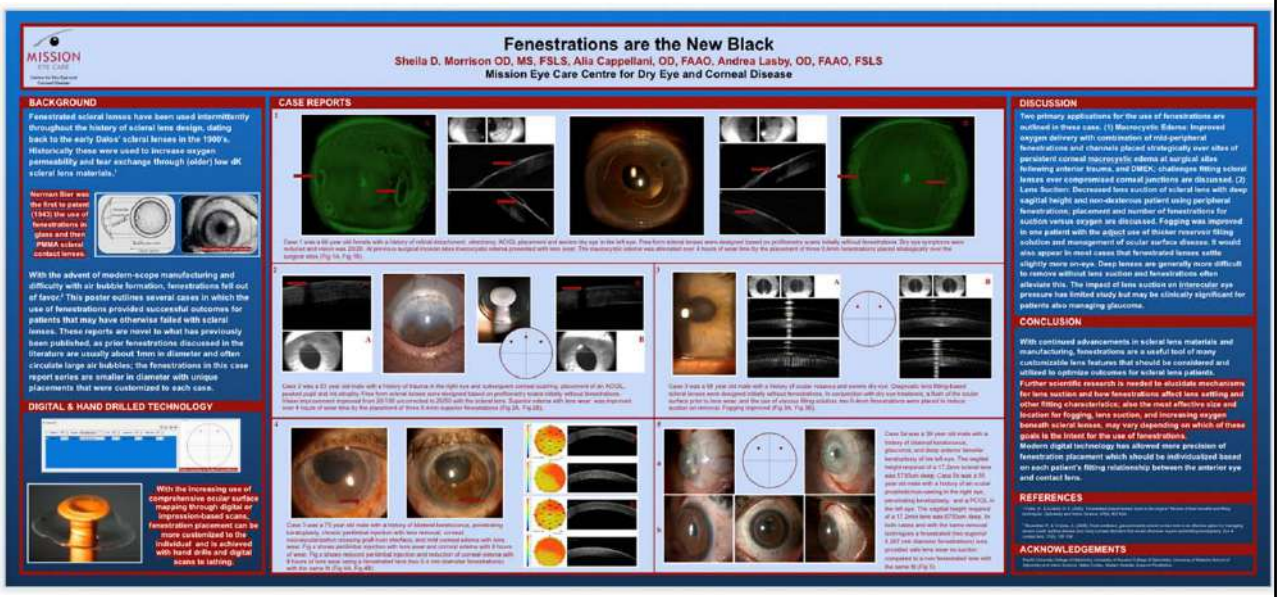
More Studies are Needed…



Fenestrations are the New Black

Sheila D. Morrison OD, MS, FSLS, Alia Cappellani, OD, FAAO, Andrea Lasby, OD, FAAO, FSLS

Mission Eye Care Centre for Dry Eye and Corneal Disease

BACKGROUND

Fenestrated scleral lenses have been used intermittently throughout the history of scleral lens design, dating back to the early Dallos' scleral lenses in the 1900's. Historically these were used to increase oxygen permeability and tear exchange through (older) low dK scleral lens materials.[1]

Norman Bier was the first to patent (1943) the use of fenestrations in glass and then PMMA scleral contact lenses.

With the advent of modern-scope manufacturing and difficulty with air bubble formation, fenestrations fell out of favor.[2] This poster outlines several cases in which the use of fenestrations provided successful outcomes for patients that may have otherwise failed with scleral lenses. These reports are novel to what has previously been published, as prior fenestrations discussed in the literature are usually about 1mm in diameter and often circulate large air bubbles; the fenestrations in this case report series are smaller in diameter with unique placements that were customized to each case.

DIGITAL & HAND DRILLED TECHNOLOGY

With the increasing use of comprehensive ocular surface mapping through digital or impression-based scans, fenestration placement can be more customized to the individual and is achieved with hand drills and digital scans to lathing.

CASE REPORTS

DISCUSSION

Two primary applications for the use of fenestrations are outlined in these case. (1) Macrocystic Edema: Improved oxygen delivery with combination of mid-peripheral fenestrations and channels placed strategically over sites of persistent corneal macrocystic edema at surgical sites following anterior trauma, and DMEK; challenges fitting scleral lenses over compromised corneal junctions are discussed. (2) Lens Suction: Decreased lens suction of scleral lens with deep sagittal height and non-dexterous patient using peripheral fenestrations; placement and number of fenestrations for suction versus oxygen are discussed. Fogging was improved in one patient with the adjunct use of thicker reservoir filling solution and management of ocular surface disease. It would also appear in most cases that fenestrated lenses settle slightly more on-eye. Deep lenses are generally more difficult to remove without lens suction and fenestrations often alleviate this. The impact of lens suction on intraocular eye pressure has limited study but may be clinically significant for patients also managing glaucoma.

CONCLUSION

With continued advancements in scleral lens materials and manufacturing, fenestrations are a useful tool of many customizable lens features that should be considered and utilized to optimize outcomes for scleral lens patients.

Further scientific research is needed to elucidate mechanisms for lens suction and how fenestrations affect lens settling and other fitting characteristics; also the most effective size and location for fogging, lens suction, and increasing oxygen beneath scleral lenses, may vary depending on which of these goals is the intent for the use of fenestrations.

Modern digital technology has allowed more precision of fenestration placement which should be individualized based on each patient's fitting relationship between the anterior eye and contact lens.

REFERENCES

ACKNOWLEDGEMENTS

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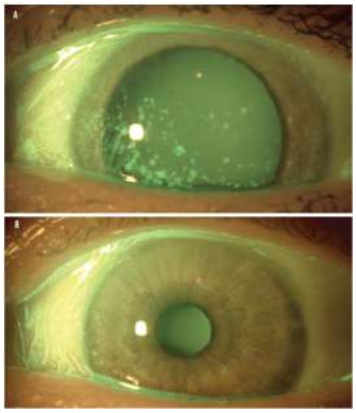
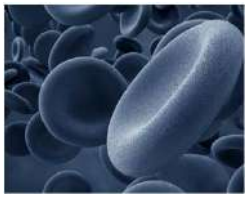


Effect of autologous platelet-rich plasma on persistent corneal epithelial defect after infectious keratitis



Lacrimal gland injection of platelet rich plasma for treatment of severe dry eye: a comparative clinical study

Autologous Platelet-rich Plasma Eye Drops in the Treatment of Recurrent Corneal Erosions

Jun Hun Lee[1], Myung Jun Kim[1], Sang Won Ha[2], Hong Kyun Kim[1]

[1]Department of Ophthalmology, Kyungpook National University School of Medicine, Daegu, Korea
[2]Cheil Eye Hospital, Daegu, Korea

Blood Biologics in Scleral Lenses…

- Lots of uses in Medicine: joints, hair follicles, skin…
- Used on facial tightening
- Dry eye : composition of PRP is similar to natural tears
- Decreases inflammation and improves cell recovery: platelets contain growth factors, vitamins & cytokines
- Access is getting better

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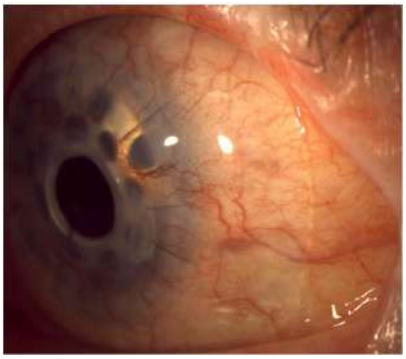

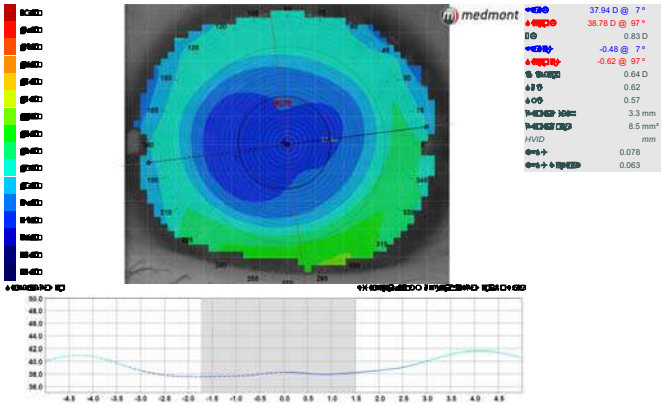

Custom Soft Reverse Curve – *Post Refractive Shapes*

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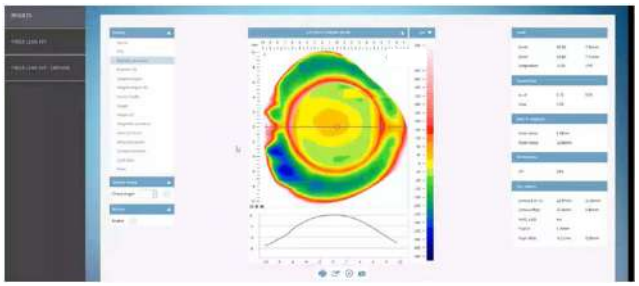
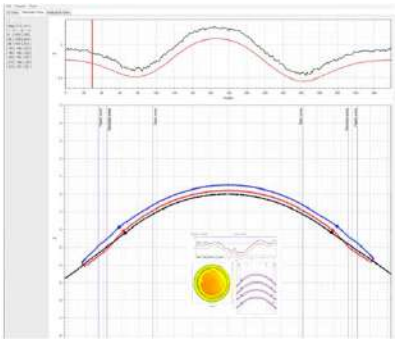
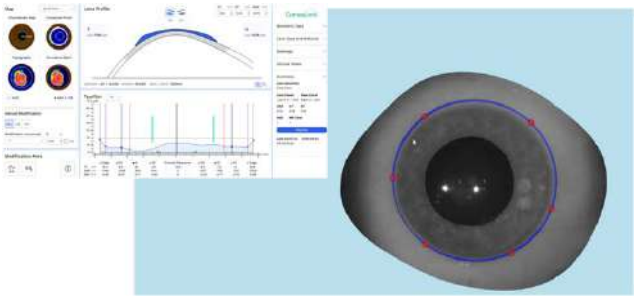
Digital Age Is Here to Stay:

Empirical design software for all specialty lens modalities







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Future Uses of CL?

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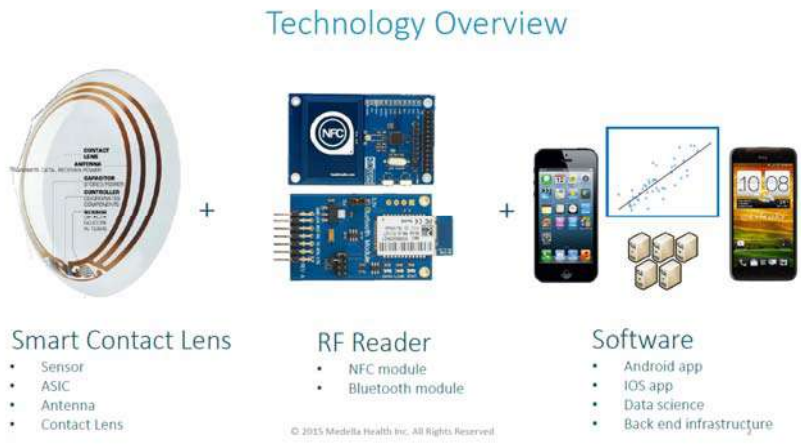
“Smart” CL System



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Diagnosis & Screening for Systemic Disease

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Systemic Disease Biomarkers

Table 1
Systemic disease biomarkers found within the tear film.

Disease	Potential tear biomarkers
Alzheimer's disease	Increased levels of dermcidin, lacritin, lipocalin-1 and lysozyme-C [2]
Cancer	Increased levels of lacryglobin [3,4], changes in combination of specific proteins [5]
Cystic fibrosis	IL-8 and IFN-γ [6], MIP-1α [7] and MIP-1β [8]
Diabetes	Increased levels of glucose [9], advanced glycation end products [10], cytokine changes [11]
Multiple sclerosis	Oligoclonal bands of IgG [12,13] and α-1-antichymotrypsin [14]
Parkinson's disease	TNF-α [15] and oligomeric alpha-synuclein [16]
Thyroid disease	IL-1β, IL-6, IL-17, TNF-α [17] and IL-7 [18]

IL – Interleukin; IFN – Interferon; MIP – Macrophage inflammatory protein; TNF – tumor necrosis factor; IgG – Immunoglobulin G.

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Jones et al.: CLEAR - Contact lens technologies of the future. Cont Lens Anterior Eye 2021; 44;2: 398-430.

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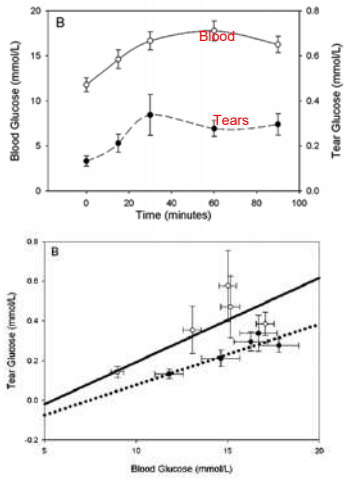
Blood vs Tear Glucose

- Poor correlation between blood and tears for glucose levels in non-diabetics
- Excellent correlation for diabetics (R^2>0.8)
- Unable to develop a viable CL-based detection product at that time due to technical limitations



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Lane *et al*. Tear glucose dynamics in diabetes mellitus. Curr Eye Res 2006;31:895-901

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Diagnosis & Screening for Ocular Disease

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CL Monitoring Devices: Glaucoma

- Sensimed Triggerfish®
- “Smart" contact lens with tiny embedded strain gauge to monitor curvature of the eye over a period of 24 hours
- Looks at relative changes in IOP
  - not absolute values
- Silicone-based (Dk~350)
- Thickness ~ 600µm
  - Dk/t ~ 60
    - hypoxia with overnight wear
- Single-use only

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1. Mansouri & Weinreb (2012). Continuous 24-hour intraocular pressure monitoring for glaucoma--time for a paradigm change. Swiss Med Wkly, 142, w13545.
2. Mansouri & Weinreb (2012). Meeting an unmet need in glaucoma: continuous 24-h monitoring of intraocular pressure. Expert Rev Med Devices, 9(3), 225-231
3. Lorenz, et al. (2013). Tolerability of 24-hour intraocular pressure monitoring of a pressure-sensitive contact lens. J Glaucoma, 22(4), 311-316.
4. Mansouri et al (2015). Efficacy of a contact lens sensor for monitoring 24-h intraocular pressure related patterns. PLoS One, 10(5), e0125530.

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CL Monitoring Devices: Other Opportunities

- Dry eye diagnosis and monitoring
  - osmolarity [1]
  - inflammatory cytokines [2]
    - TNF-α, IL-6, IL-17a and IL-8
- Blink monitoring [3]
- Ocular surface temperature [4]
- Ocular surface vasculature responses [5]

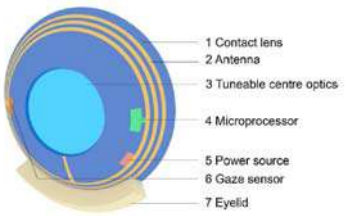

Fig. 3. Schematic design of an electronic presbyopic contact lens [425]. The sensor monitors (6) the gaze and sends the information to a microprocessor (4), which controls the tuneable centre optics (3). The optics can be tuned using a responsive polymer [435] or liquid crystals [424,425,436]. The entire system is supported by a power source (5) and an antenna (2).

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1. Chiou JC: The Development of Smart Contact Lens System: Taking Dry Eye Syndrome Diagnosis as an Example. Future Tech Expo 2019 2019; https://www.futuretech.org.tw/futuretech/index.php?action=product_detail&prod_no=P00087000001856&web_lang=en-us.
2. Roy et al.: The Growing Need for Validated Biomarkers and Endpoints for Dry Eye Clinical Research. Invest Ophthalmol Vis Sci 2017; 58;6: BIO1-BIO19.
3. Pugh et al.: Blink detection system for electronic ophthalmic lens, U.P. Office, Editor. 2015, Johnson and Johnson Vision Care Inc.
4. Moreddu et al.: Contact lenses for continuous corneal temperature monitoring. RSC Advances 2019; 9;20: 11433-11442.
5. Ho & Amirparviz: Contact lens with intergrated pulse oximeter, U.P. Office, Editor. 2015, Google Inc. p. 25.

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Treatment of Ocular Conditions: Drug Delivery

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What about using CL as a delivery vehicle?

- Soaked CL will release drugs much slower and enhance ocular availability
- First suggested in original Wichterle hydrogel patents in 1960's [1]
  - first published manuscript in 1971 [2]
- >90% of surveyed clinicians would be interested in using a drug delivering CL [3]
- Clinical success depends on
  - drug loading
  - drug release

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1. Wichterle & Lim. Cross-linked hydrophilic polymers and articles made therefrom. US patent: 3220960; 1965
2. Morgan. A new drug delivery system for the eye. IMS Ind Med Surg 1971;40:11-3.
3. Karlgard *et al.* Survey of bandage lens use in North America, October-December 2002. Eye Contact Lens 2004; 30;1: 25-30.

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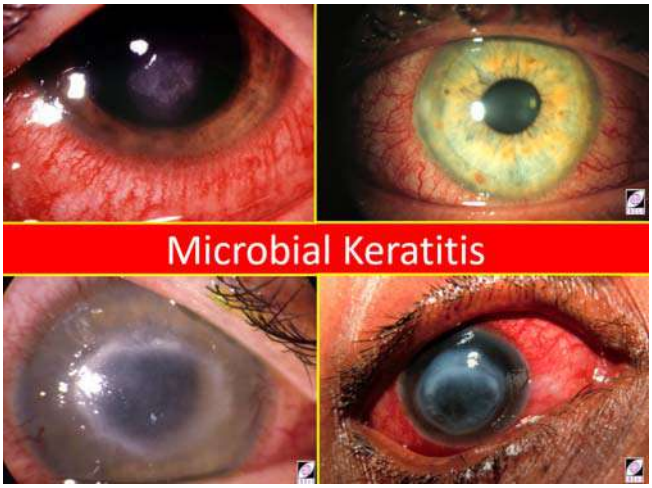
Relevant diseases: short-term therapy



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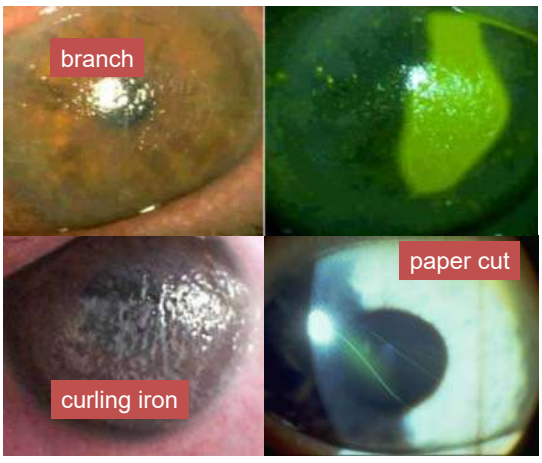
Severe corneal abrasions



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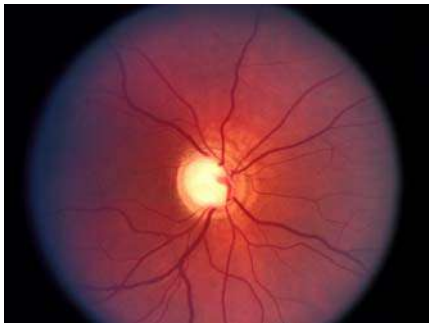
Relevant diseases: long-term therapy

- Ocular allergy
- Glaucoma



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Commercial Reality:

Licensed in Japan & Canada May 2021; USA Mar 2022

- J&J Acuvue Theravision® with Ketotifen
  - topical antihistamine
- "Itchy eye relief"
  - allergic conjunctivitis
- Daily disposable platform
  - etafilcon A
  - hydrogel; 58% water content
  - preservative free
  - releases product over 5 hrs
  - provides up to 12 hr relief

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1. Pall et al. Management of Ocular Allergy Itch With an Antihistamine-Releasing Contact Lens. Cornea 2019; 38;6: 713-717.
2. Pall & Sun. Evaluation of corneal staining with an antihistamine-releasing contact lens. Clin Exp Optom 2022 1-6.
3. https://contactlensupdate.com/2021/04/28/the-ex-vivo-drug-amount-of-an-antihistamine-releasing-contact-lens/

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Optical Enhancements

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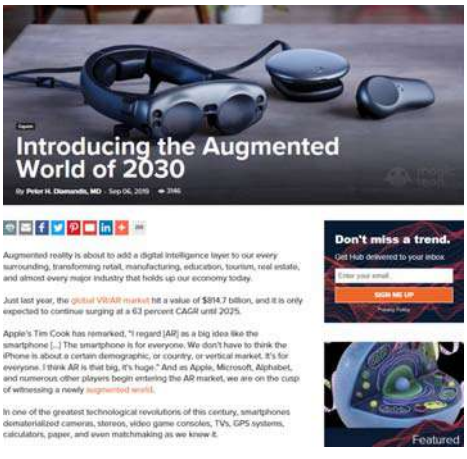
Augmented & Virtual Reality

- VR - completely immerses users in digital realities
- AR - allows users to remain engaged with their physical surroundings, serving as a visual enhancement rather than replacement
- In 2018 the global VR/AR market hit a value of $814.7 billion
  - expected to continue surging at a 63% annual growth until 2025



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Augmented Reality for Training

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Press Release

Web Version

Ophthalmology TIMES

April 19, 2022

Alcon introduces VR surgical training technology

This advancement reinforces Alcon's commit education, as part of the Alcon Experience A introduced at the upcoming ASCRS meeting experience the new technology firsthand. Read here

Alcon recently introduced its new Alcon Fidelis™ Virtual Reality (VR) Ophthalmic Surgical Simulator, a portable VR tool for cataract surgeons-in-training. This advancement reinforces Alcon's longstanding commitment to surgeon training and education, as part of the Alcon Experience Academy.

"The VR simulator offers a high-fidelity, virtual operating room environment with haptic feedback to simulate the look and feel of cataract sugery2," a press release states. "The simulator can be used from any location around the world with the ability to invite others to join virtual instruction and training sessions."

This latest innovation in surgical training is an important step in increasing access to surgical simulators around the world.

Using surgical stimulators, the eye care industry has already seen benefits of improved performance in the operating room (OR), as seen in a study showing a 38% rate of improvement for surgeons with fewer than 75 independent surgeries performed.1*

Providing cutting-edge options for realistic, remote surgical training can help mitigate some of the time constraints ophthalmologists are facing, as well as provide access to educational tools for those in countries where training resources are limited, the release notes.

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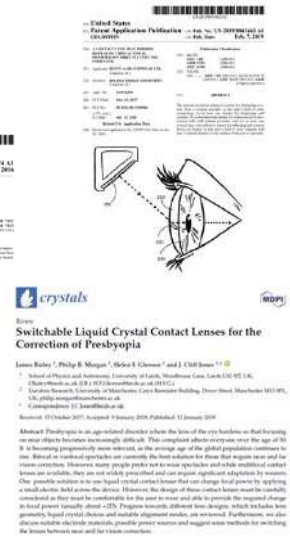
Unique Optical Opportunities

- Head-up displays
- Magnifying CL
  - low vision
- Accommodating CL
  - presbyopia
- Camera in a lens
- Facial recognition



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Summary

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Summary

- Incredible diversity of new technologies under development that will shape the future for CL
- Amazing new developments in SiHy & DD materials
- Myopia management and specialty lens options continue to grow at a rapid rate
- Rapid growth in novel biomaterials and the development of powered CL through advancements in nanotechnology will enable the commercialisation of “crazy, sexy” lenses!
- Contact lenses have been around for over 100 years - and their future remains bright

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THANK YOU

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