

The Great Debate: Silicone Hydrogels vs Hydrogels

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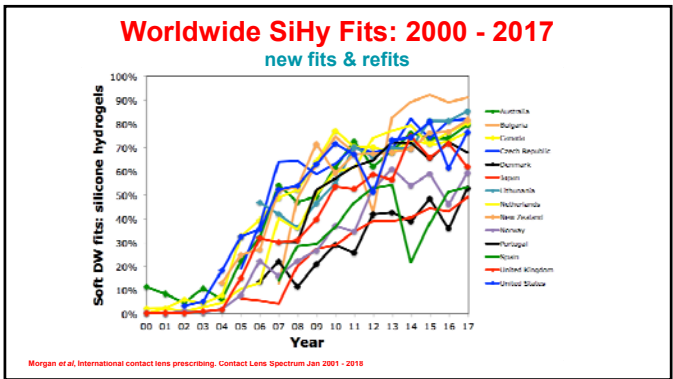
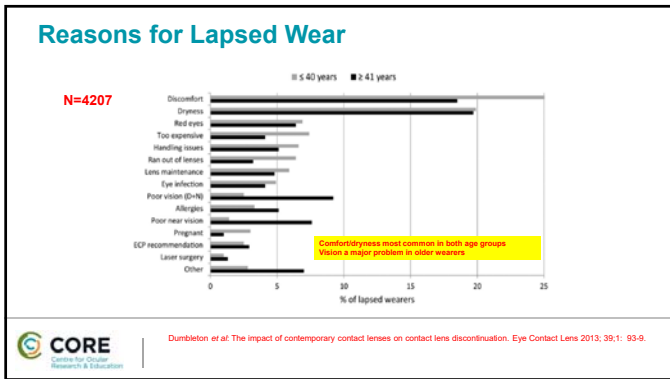
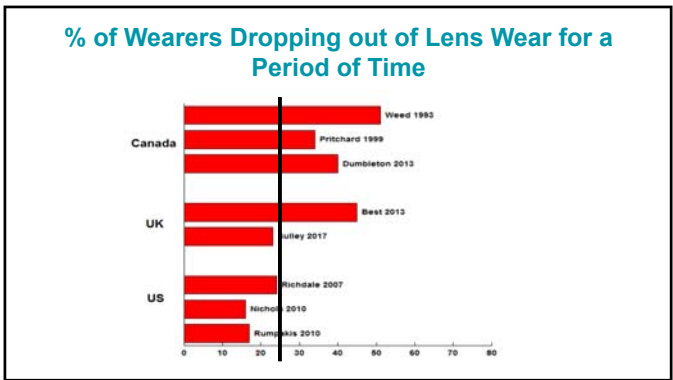
Financial Disclosures

Over the past three years, members of CORE have received research funding and/or honoraria from the following 15 companies & 3 funding agencies:

- Alcon
- Allergan
- Contamac
- CooperVision
- GL Chemtec
- Inflamox Research
- Johnson & Johnson Vision
- Menicon
- Nature's Way
- Novartis
- Safilens
- Santen
- Shire
- SightGlass
- Visioneering

Biggest Challenge for CL Practitioners?

1. Chalmers & Bejley. Dryness symptoms among an unselected clinical population with and without contact lens wear. *Contact Lens* 2008; 28(1): 25-30.
 2. Nichols & Smith. Tear film, contact lens, and patient-related factors associated with contact lens-related dry eye. *Invest Ophthalmol Vis Sci* 2008; 47(4): 1319-28.
 3. Fonn. Targeting contact lens material dryness and discomfort: what properties will make lenses more comfortable. *Optom Vis Sci* 2003; 80(4): 273-80.
 4. Ramamoorthy et al. Treatment, material, care, and patient-related factors in contact lens-related dry eye. *Optom Vis Sci* 2008; 85(8): 764-72.
 5. Chalmers et al. Discomfort with hydrogel CL wear increases with age in young adults. *Contact Lens* 2008; 28(1): 11-24.



Silicone Hydrogel Benefits

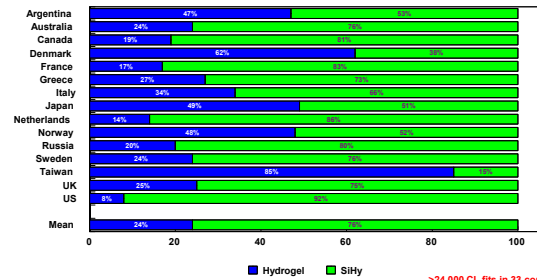
- Hypoxia related complications - problem solved!
 - overnight oedema ~3% ^{1,2}
 - no increase in microcysts ^{2,3}
 - min limbal hyperaemia ^{2,4}
 - min vascularisation ⁵
 - no myopic creep ⁶



1. Fonn D et al. OVS 1999; 40:13
2. Fonn D et al. Clin Exp Optom 2002; 85:3
3. Covey M et al. OVS 2001; 78:2
4. Pappa E et al. Curr Eye Res 1997; 16:9
5. Dumbleton KA et al. OVS 2001; 78:3
6. Dumbleton KA et al. OVS 1999; 76:12

Worldwide SCL Fits: 2018

new fits & refits



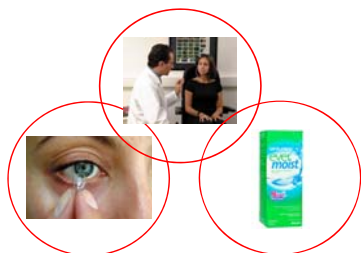
Morgan et al. International contact lens prescribing in 2018. Contact Lens Spectrum 2019; 34(1): 26 - 32. >24,000 CL fits in 33 countries

How Have Hydrogels Survived?

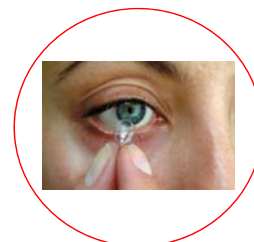
What drives better comfort?



Three Factors...



Material Factors...



Contact Lens & Tear Film

Consider the relative thickness of the tear film and the CL it supports.

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Craig JP et al. The TFOS International Workshop on Contact Lens Discomfort: report of the contact lens interactions with the tear film subcommittee. Invest Ophthalmol Vis Sci 2013;54:TFOS123-56

Contact Lens in the Tear Film

Image courtesy of Jay Wang

Reduced PLNIBUT vs NIBUT: Impact of Contact Lens

Condition	TBUT (secs)
No lens in situ	~35
After 1 hr	~8
1 hr post removal	~22

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Faber et al. Effect of hydrogel lens wear on tear film stability. Optom Vis Sci 1991; 68:5: 380-4.

Blinking & Tear Film Breakup

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Guillon et al. Association Between Contact Lens Discomfort and Pre-lens Tear Film Kinetics. Optom Vis Sci 2016; 93:8: 881-91.

Development of Surface Aberrations

No Lens

SCL in Place

Aberrations & Dry Eye

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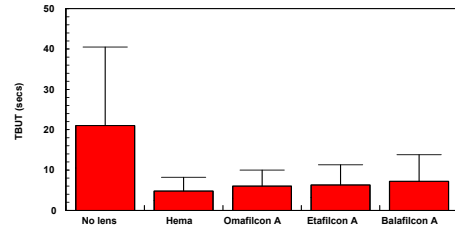
- Koh et al. Serial measurements of higher-order aberrations after blinking in patients with dry eye. Invest Ophthalmol Vis Sci 2008; 49:1: 133-8.
- Koh et al. Effects of suppression of blinking on quality of vision in borderline cases of evaporative dry eye. Cornea 2008; 27:3: 275-8.

Question

- Which lens material has been shown to provide the longest PLNIBUT in eye?
 - Hydrogels
 - Silicone hydrogels
 - No difference



Reduced PLNIBUT vs NIBUT: Impact of Material



Thai et al.; Effect of contact lens materials on tear physiology. *Optom Vis Sci* 2004; 81:3: 194-204.

Wettability: Hydrogels vs SiHy

REVIEW ARTICLE
Wettability and Silicone Hydrogel Lenses: A Review
Nancy Keir, MSc, PhD and Lyndon Jones, PhD

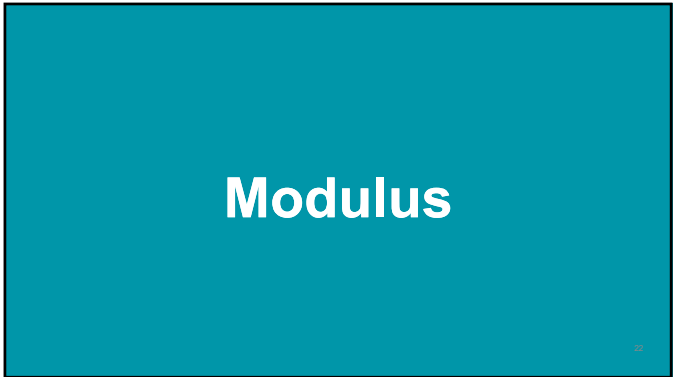
Abstract: One of the major breakthroughs in the development of silicone hydrogel contact lenses has centered on the ability of manufacturers to overcome the surface hydrophobicity that occurred with silicon elastomer lenses. However, the wettability of silicone hydrogel lenses continues to be of interest as a general risk factor to lens lens performance and contact lens related comfort. This article will review some of the knowledge we have gained in the area of contact lens wettability over the past decade and will discuss some of the challenges related to its measurement.

Key Words: Wettability; Contact lens; Silicone hydrogel; Tear film; Contact.

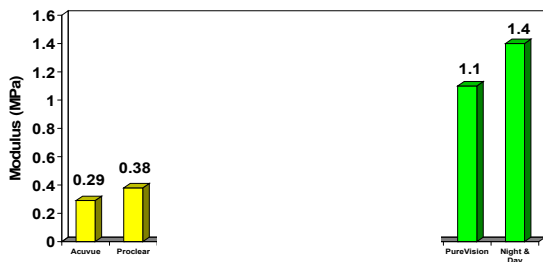
What Makes a Contact Lens "Wettable"?
 "Wetting" refers to the contact between a solid surface and a liquid and depends on the intermolecular interactions. In the eye, the term "wettability" typically refers to the ability of the tear film to coat and maintain itself over the surface of a contact lens, and is considered an essential factor in determining the lens/wearer compatibility. A wettable contact lens surface is important for many reasons, including reduced tear surface disruption, improved optical quality, and comfort. The contact surface response to wettability in several ways, the most significant of which is the PCV. Historically, it was expected



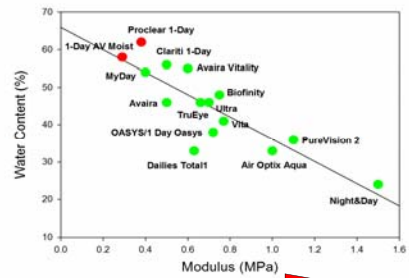
Keir & Jones. Wettability and silicone hydrogel lenses: a review. *Eye Contact Lens* 2013; 39:1: 100-8.



Modulus Over Time

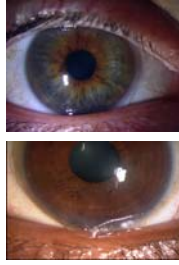


Water Content vs Modulus



Soft Lens Fit

- Excessive movement results in reduced comfort ^{1,2,3}
- Be wary of fitting excessively mobile SiHy
 - fit may be different to hydrogels due to
 - modulus
 - thickness/design
 - edge shape
 - may need a steeper base curve ⁴



1. Houkai et al. An evaluation of the 8.4mm and the 8.8mm base curve radii in the CBA Necrosis vs. the Vistakon Acuvue. *KLCC 1994*; 21: 12: 14-17.
 2. Young. Evaluation of soft contact lens fitting characteristics. *Optom Vis Sci* 1998; 75: 247-254.
 3. Jones et al. The TFOS International Workshop on Contact Lens Discomfort: report of the contact lens materials, design, and care subcommittee. *Invest Ophthalmol Vis Sci* 2013; 54:11: TFOS17-16.
 4. Dunbabin et al. Effect of lens base curve on subjective comfort and assessment of fit with silicone hydrogel continuous wear contact lenses. *Optom Vis Sci* 2002; 79: 10: 633-7.

Deposition

Visible Deposits



Deposit Summary for SiHy

- Very low levels of protein
 - but often denatured and surface located
- Lipid deposits higher than conventional materials
 - in some patients
 - lower in surface treated materials
- Clinical relevance
 - not all deposits may be bad?
 - denatured protein and lipid is hard to remove without physical rub/rinse
 - may be that hydrogels “integrate” better with the tear film?



1. Subbaraman et al. Kinetics of in-vitro lysozyme deposition on silicone hydrogel, PMMA, and FDA group 1, 6, and 9 contact lens materials. *Cont Lens* 2006; 31:10: 787-96.
 2. Jones & Jones. Lipid deposition on hydrogel contact lenses: how long will they last? *Optom Vis Sci* 2007; 84: 38-50.
 3. Subbaraman & Jones. Kinetics of lysozyme activity measured from conventional and silicone hydrogel contact lens materials. *J Biomed Sci Eng* 2010; 2(10): 343-58.
 4. Subbaraman & Jones. Protein deposition on contact lenses: the role of protein and the lens. *Cont Lens* 2010; 35(10): 70-84.
 5. Wilson. Deposition on silicone hydrogel lenses. *Exp Contact Lens* 2012; 5(1): 19-22.
 6. Taylor et al. In vivo cholesterol deposition on daily disposable contact lens materials. *Optom Vis Sci* 2014; 91: 18-21.
 7. Taylor et al. Sensitivity and correlation of lysozyme uptake in conventional contact lens materials. *J Biomed Sci Eng* 2017; 10(10): 1039-1046.

Patient Factors...



Allergy

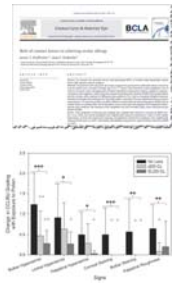
- 1/3rd population suffer from an allergy ¹
 - incidence of allergies is increasing
- Significant and growing problem eye care practitioners will encounter in everyday practice
- Sufferers likely to visit eye care practitioner ²
 - 13% attending an optometric practice in UK ³



1. European Allergy White Paper, UCB Institute, London
 2. Global Allergy and Asthma European Network
 3. Wollschlaeger et al. Prevalence and impact of ocular allergy in the population attending UK optometric practice. *Cont Lens* 2011; 34:3: 133-6.

DD Hydrogels are Protective

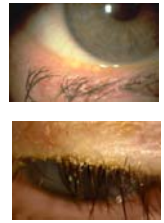
- Daily disposable contact lenses offer a protective barrier to airborne antigens
 - symptoms of burning and stinging were significantly reduced in severity
 - symptoms were significantly reduced in duration
 - bulbar hyperaemia, corneal and conjunctival staining, palpebral conjunctival roughness, limbal and palpebral conjunctival redness reduced



1. Hayes et al.: An evaluation of 1-day disposable contact lens wear in a population of allergy sufferers. *Cont Lens Anterior Eye* 2003; 26:2: 85-93.
 2. Wolffsohn & Emberlin: Role of contact lenses in relieving ocular allergy. *Cont Lens Anterior Eye* 2011; 34:4: 169-72.

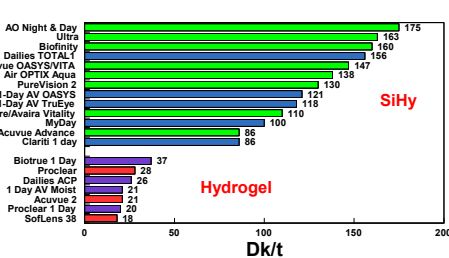
Tear Film Quality & Lid Abnormalities

- MGD and blepharitis associated with
 - reduced tear film quality
 - reduced CL surface wettability
 - increased gram positive toxins in the tear film
- Best managed with DD lens materials



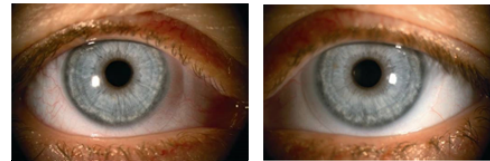
1. Doolan et al.: Lid flora in blepharitis. *Cornea* 1991; 10:1: 85-5.
 2. Baskin et al.: Blepharitis. *Infect Dis Clin North Am* 1992; 6:4: 777-87.
 3. Smith & Fawcett: Ocular Blepharitis: a review. *CLAO J* 1998; 21:3: 203-7.
 4. Jackson: Blepharitis: current strategies for diagnosis and management. *Can J Ophthalmol* 2008; 43:2: 170-9.
 5. Lindquist et al.: Interventions for chronic blepharitis. *Cochrane Database Syst Rev* 2012; 1:6: CD009556.
 6. Tawabemetehi et al.: Bacterial profile of ocular infections: a systematic review. *BMC Ophthalmol* 2017; 17:1: 212.

Oxygen Transmissibility (Dk/t)



1. SiHy values from manufacturers quoted below.
 2. Hydrogel values calculated from Morgan & Ertel. The oxygen performance of contemporary hydrogel contact lenses. *CLAE* 1998;21:3-6.

Patients vary in their oxygen needs...



Same patient wearing DD hydrogel in their right eye and DD SiHy in their left eye for an eight hour period, with a noticeable difference in limbal hyperaemia



Jones & Woods: An eye on the world's first silicone hydrogel daily disposable contact lens. *Optician* 2008; 236:6/72: 33 - 34.

Corneal Swelling for DW?

ORIGINAL ARTICLE

Corneal Swelling with Cosmetic etafilcon A Lenses versus No Lens Wear

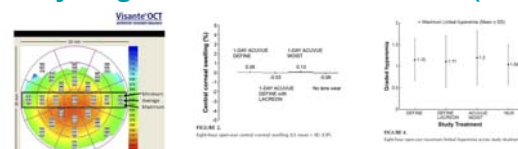
Alex M. Moezzi¹, Jitabh Varshney², Mani Shalvi³, William Ng⁴, Katherine O'Hara-Lane⁵, David B. Storz⁶, and London W. Jones⁷

ABSTRACT The objective of this study of patients at varying degrees of dry eye during the evaluation of 8-hour wear (8HW) of cosmetic etafilcon A lenses versus no lens wear (NLW). **DESIGN** A randomized, double-masked, controlled trial comparing 8HW of cosmetic etafilcon A lenses versus NLW. **SETTING** A tertiary care ophthalmology clinic. **PARTICIPANTS** Patients with dry eye symptoms were recruited to the study. **MEASUREMENTS AND MAIN RESULTS** Central corneal thickness (CCT) was measured using a 200-µm probe. The mean CCT for patients wearing etafilcon A lenses was significantly higher than for patients wearing NLW. **CONCLUSIONS** The results of this study suggest that 8HW of cosmetic etafilcon A lenses is associated with increased central corneal swelling compared to NLW. **KEY WORDS** etafilcon A lenses, central corneal swelling, dry eye, contact lenses.



Moezzi et al.: Corneal swelling with cosmetic etafilcon A lenses versus no lens wear. *Optom Vis Sci* 2016; 93:6: 619-28.


Hydrogel Wear vs No Lens Wear (NLW)



- N=24
- DW of etafilcon A for 8 hrs (tinted and clear)
- Central and peripheral corneal swelling by optical pachymetry or OCT was negligible
- No significant differences between lenses and NLW for
 - corneal staining
 - limbal/bulbar hyperemia

Infiltrative Keratitis: Risk Factors

- Age
 - 15-29
- Sleeping overnight in CL
- Hygiene
 - showering in CL
 - neglected hand-washing
 - poor case hygiene
 - poor compliance with care system
- Stretching use of CL past replacement frequency
- Smoking
- Previous history of an inflammatory event



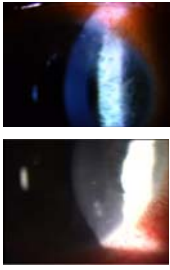
Steele & Szczoika-Flynn. Epidemiology of contact lens-induced infiltrates: an updated review. Clin Exp Optom 2017; 100.5: 473-481.

Question

- Which lens material has been shown to provide the lowest risk of corneal infiltrates?
 - a) Hydrogels
 - b) Silicone hydrogels
 - c) No difference

Infiltrative Keratitis: Reusable CL

- Difficult to accurately report incidence rates
 - results depend on:
 - study design
 - criteria used for reporting infiltrates
- Consistently **2X higher rate with reusable SiHy**¹⁻⁵



1. Szczoika-Flynn & Diaz Optom Vis Sci 2007; 2. Radford et al Ophthalmology 2009; 3. Chalmers et al Optom Vis Sci 2010; 4. Chalmers et al IOVS 2011; 5. Chalmers et al Optom Vis Sci 2012

Infiltrative Keratitis & DD Contact Lenses

Age and Other Risk Factors for Corneal Infiltrative and Inflammatory Events in Young Soft Contact Lens Wearers from the Contact Lens Assessment in Youth (CLAY) Study

Robins L, Chalmers, Hirst, Wagner, G, Lynn, Mitchell, Hirst, F, Lane, B, Bell, Marshall, J, Jones, K, Kothiyil, Richards, Longue, Swanson, and Timothy F. McManus

Multicenter Case-Control Study of the Role of Lens Materials and Care Products on the Development of Corneal Infiltrates

Robins L, Chalmers, Liu King, John McNally, and Jami Kim

"12x lower risk of IK with DD lenses"

1. Chalmers et al. Age and other risk factors for corneal infiltrative and inflammatory events in young soft contact lens wearers from the Contact Lens Assessment in Youth (CLAY) study. Invest Ophthalmol Vis Sci 2011; 52:9: 6690-6.
2. Chalmers et al. Multicenter case-control study of the role of lens materials and care products on the development of corneal infiltrates. Optom Vis Sci 2012; 89:3: 316-25.

Infiltrative Keratitis & DD: Hydrogel vs SiHy

- 1171 subjects (960 years of wear)
 - 489 years of SiHyDD (1-Day Acuvue TruEye)
 - 471 years of HydDD (1-Day Acuvue Moist)
- Adverse events recorded and practice records reviewed
- **Only 1% had SCL complications that prompted visits to ECP**
- SiHy DD = HydDD
- Risk factors associated with recorded events
 - overnight wear = 30%
 - storage & reuse = 21%
 - >5.0D = 22%
 - Age <25 years = 31%

Chalmers et al. Rates of adverse events with hydrogel and silicone hydrogel daily disposable lenses in a large postmarket surveillance registry: The TEMPO Registry. Invest Ophthalmol Vis Sci 2015; 56:1: 654-63.

Solution Factors...



Biocide Uptake/Release?

Contents lists available on ScienceDirect
Contact Lens & Anterior Eye BCLA
 Journal homepage: www.elsevier.com/locate/clae

Lipophilic versus hydrodynamic modes of uptake and release by contact lenses of active entities used in multipurpose solutions
 Charles H. Powell^a, John M. Lally, Lisa D. Hoang, Stanley W. Huth

ARTICLE INFO
 Paper: The absorption of the chlorhexidine component of some high Dk lens materials correlates...

CORE Centre for Ocular Research & Education

1. Powell et al., CLAE 2010; 33: 9-18. Lipophilic versus hydrodynamic modes of uptake and release by contact lenses of active entities used in multipurpose solutions. Cont Lens Anterior Eye 2010; 33(1): 9-18.
2. Jones & Powell. Uptake and release phenomena in contact lens care by silicone hydrogel lenses. Eye Contact Lens 2013; 39(1): 29-36.

Corneal Staining

Clinically Relevant?

Comfort: Hydrogels vs SiHy?

Question

- Which lens material has been shown to be the most comfortable in extensive reviews of the literature?

- a) Hydrogels
- b) Silicone hydrogels
- c) No difference

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Comfort: Reusable Hydrogel vs SiHy?

Are Silicone Hydrogel Contact Lenses More Comfortable Than Hydrogel Contact Lenses?

Impact of Contact Lens Material, Design, and Fitting on Discomfort

The TFOS International Workshop on Contact Lens Discomfort: Report of the Contact Lens Materials, Design, and Care Subcommittee

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1. Gullon: Are silicone hydrogel contact lenses more comfortable than hydrogel contact lenses? Eye Contact Lens 2013; 39(1): 86-92.
2. Jones et al.: The TFOS International Workshop on Contact Lens Discomfort: report of the contact lens materials, design, and care subcommittee. Invest Ophthalmol Vis Sci 2010; 51(11): 11633-70.
3. Stapleton & Tan: Impact of Contact Lens Material, Design, and Fitting on Discomfort. Eye Contact Lens 2013; 41(1): 32-39.

Comfort: DD Hydrogel vs SiHy?

Comparison of Silicone Hydrogel and Hydrogel Daily Disposable Contact Lenses

Neither material types showed superiority in comfort, and adverse event rates were low with both material types.

These findings suggest that choice of material is a patient and practitioner preference; however, for patients at risk of hypoxia-related complications, SiHy materials should be considered.

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Diec et al.: Comparison of Silicone Hydrogel and Hydrogel Daily Disposable Contact Lenses. Eye Contact Lens 2018; 44 Suppl 1: S167-S172

Summary

Hydrogels vs SiHy

- SiHy materials have provided much-needed improved oxygen transport to the eye
 - hypoxic signs disappeared
 - but many subjects show no hypoxia with hydrogels on a DW basis
- No differences between hydrogels and SiHy for
 - wettability
 - comfort
 - wearing time
- Infiltrates reduced with reusable hydrogels compared with SiHy
- Hydrogels remain a viable option for CL wearers

THANK YOU