

Comparison of the Ocular Surface in Adult and Pediatric Contact Lens Wearers

Katherine M. Bickle, OD, MS

March 27, 2022

Financial Disclosures

- Research funding from Alcon, CooperVision, and Johnson and Johnson Vision Care

Contact Lens Wear

- Over 40 million contact lens wearers in the United States
- Contact lens dropout is significant (12% to 34%)
 - One of the most common reason: discomfort
 - No clear etiology for discomfort in CL wearers
- Percentage of CL wearers decreases with age

Background

- Research on ocular surface measurements in soft contact lens wearers
 - Extensive in adults but limited in the pediatric population
 - Tear Film & Ocular Surface Society (TFOS) Workshops
 - Current workshop
 - A Lifestyle Epidemic: Ocular Surface Disease (digital environment, contact lens wear, nutrition, environmental conditions, lifestyle challenges)
 - Previous workshop
 - Dry Eye Workshop (DEWS)
 - DEWS II
 - Contact Lens Discomfort
 - Meibomian Gland Dysfunction

Definitions

- *DEWS II workshop*
 - *Dry eye is a multifactorial disease of the ocular surface characterized by a loss of **homeostasis of the tear film**, and accompanied by **ocular symptoms**, in which **tear film instability** and **hyperosmolarity**, ocular surface **inflammation** and damage, and neurosensory abnormalities play etiological roles.*
- *CLD Workshop*
 - *Contact lens discomfort is a condition characterized by **episodic or persistent adverse ocular sensations related to lens wear**, either **with or without visual disturbance**, resulting from **reduced compatibility between the contact lens and the ocular environment**, which can lead to decreased wearing time and discontinuation of contact lens wear.*

Subjective Comparisons

- CLDEQ
 - Up to 50% of adults report contact lens-related dry eye
 - Only 4% of children report contact lens-related dry eye (Greiner and Walline, 2010)
- Contact Lenses in Pediatrics (CLIP) Study (Jones et al, 2009)
 - 84.6% of those ages 8-12 reported their eyes never or rarely felt dry
 - 67.2% of those ages 13-17 reported their eyes never or rarely felt dry

Ocular Surface Disease Index

Variables	Pediatric group (n=45)	Adult group (n=45)	P value*
OSDI ^a	12.82±12.82	35.61±24.85	<0.001
1. Eyes that are sensitive to light?	1.12±1.23	1.21±1.10	0.723
2. Eyes that feel gritty?	0.47±0.70	1.53±1.24	<0.001
3. Painful or sore eyes?	0.33±0.61	1.57±1.11	<0.001
4. Blurred vision?	0.21±0.72	1.50±1.23	<0.001
5. Poor vision?	0.77±1.29	1.58±1.18	0.003
6. Reading?	0.08±0.28	1.60±1.16	<0.001
7. Driving at night?	N/A	1.37±1.20	
8. Working with a computer or bank machine (ATM)?	0.62±.92	1.40±1.03	0.001
9. Watching TV?	0.37±0.71	1.48±1.22	<0.001
10. Windy conditions?	0.58±0.76	1.55±1.19	<0.001
11. Places or areas with low humidity (very dry)?	0.59±0.86	1.49±1.24	0.001
12. Areas that are air conditioned?	0.37±0.69	1.39±1.22	<0.001

Have you experienced any of the following during the last week?	All of the time	Most of the time	Half of the time	Some of the time	None of the time
1. Eyes that are sensitive to light? . . .	4	3	2	1	0
2. Eyes that feel gritty?	4	3	2	1	0
3. Painful or sore eyes?	4	3	2	1	0
4. Blurred vision?	4	3	2	1	0
5. Poor vision?	4	3	2	1	0

Subtotal score for answers 1 to 5 (A)

Have problems with your eyes limited you in performing any of the following during the last week?	All of the time	Most of the time	Half of the time	Some of the time	None of the time	N/A
6. Reading?	4	3	2	1	0	N/A
7. Driving at night?	4	3	2	1	0	N/A
8. Working with a computer or bank machine (ATM)?	4	3	2	1	0	N/A
9. Watching TV?	4	3	2	1	0	N/A

Subtotal score for answers 6 to 9 (B)

Have your eyes felt uncomfortable in any of the following situations during the last week?	All of the time	Most of the time	Half of the time	Some of the time	None of the time	N/A
10. Windy conditions?	4	3	2	1	0	N/A
11. Places or areas with low humidity (very dry)?	4	3	2	1	0	N/A
12. Areas that are air conditioned? . . .	4	3	2	1	0	N/A

Subtotal score for answers 10 to 12 (C)

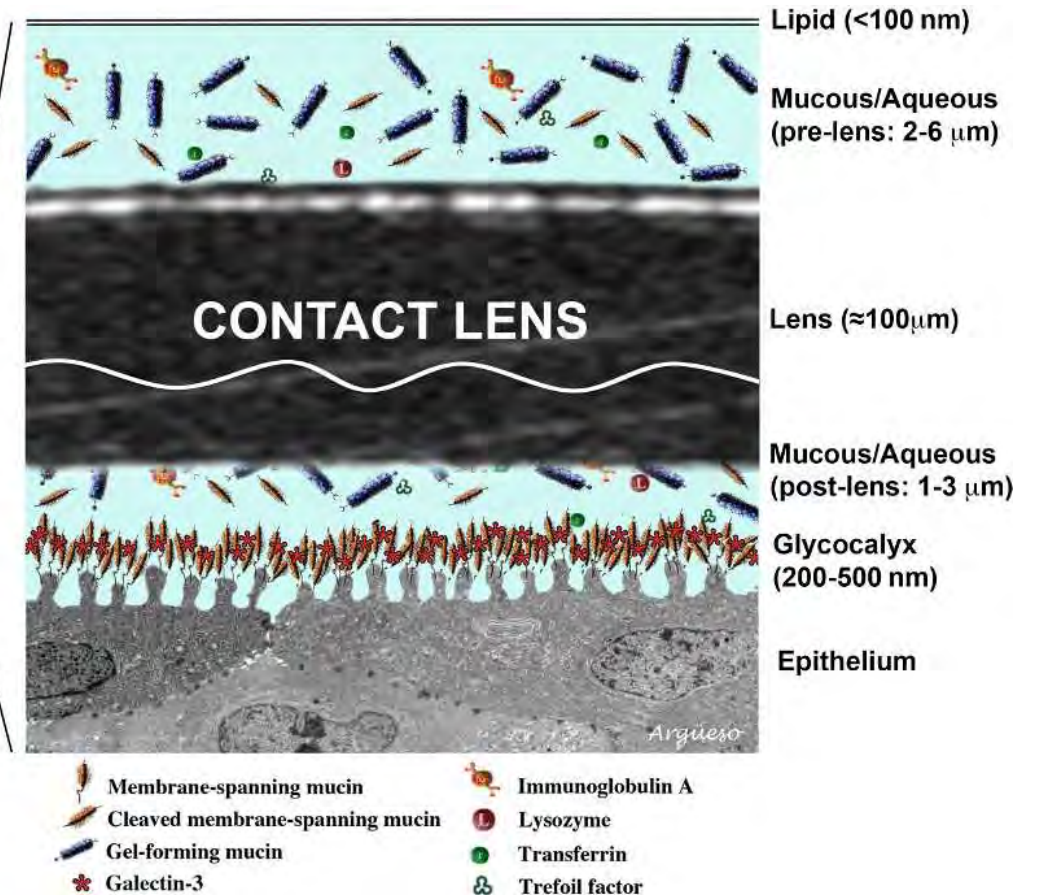
Add subtotals A, B, and C to obtain D (D = sum of scores for all questions answered) (D)

Total number of questions answered (do not include questions answered N/A) (E)

Please turn over the questionnaire to calculate the patient's final OSDI[®] score.

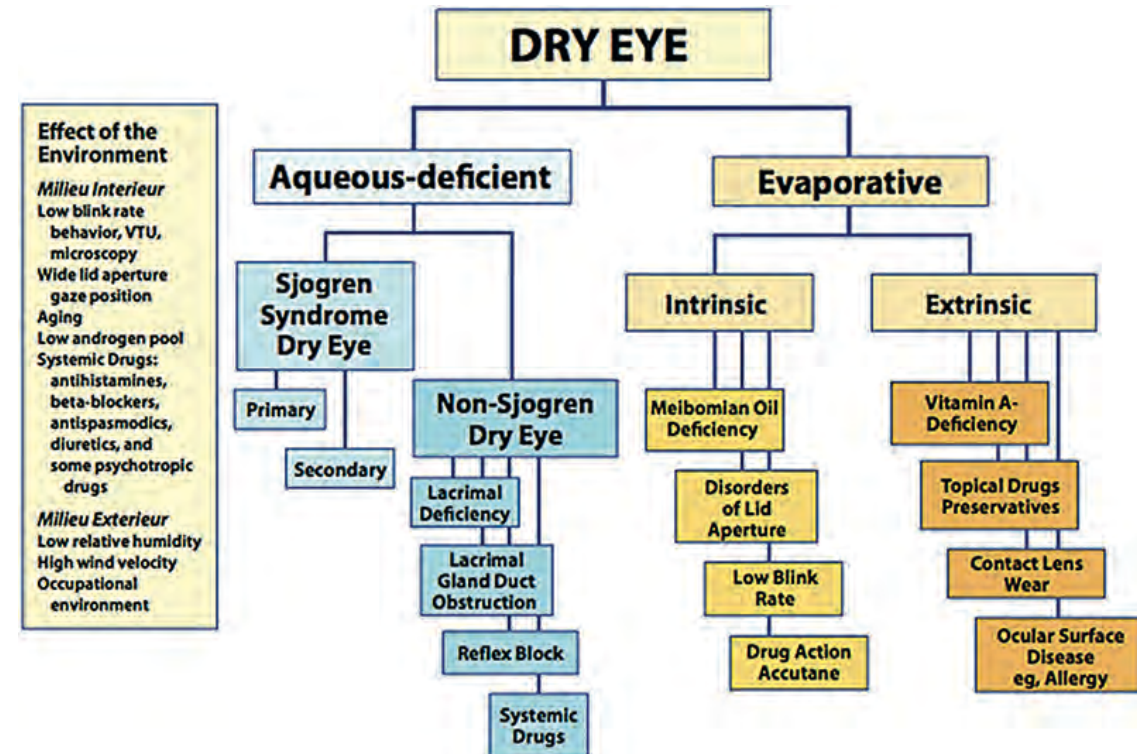
Interaction with a Contact Lens and the Tear Film

- Contact lens wear results in separation of tear film into pre- and post-lens tear film



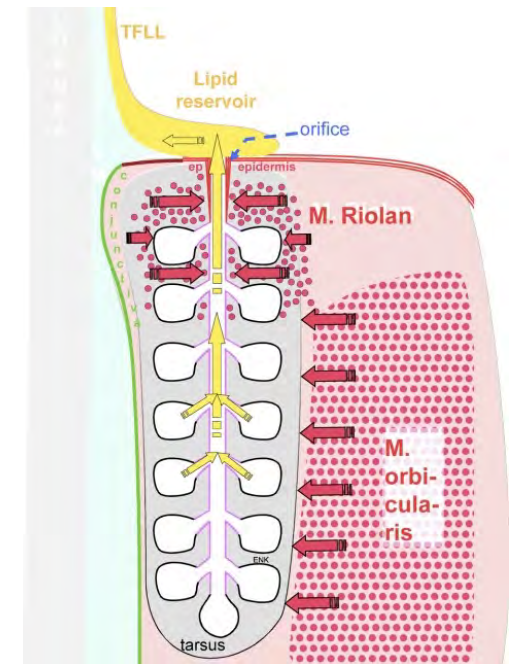
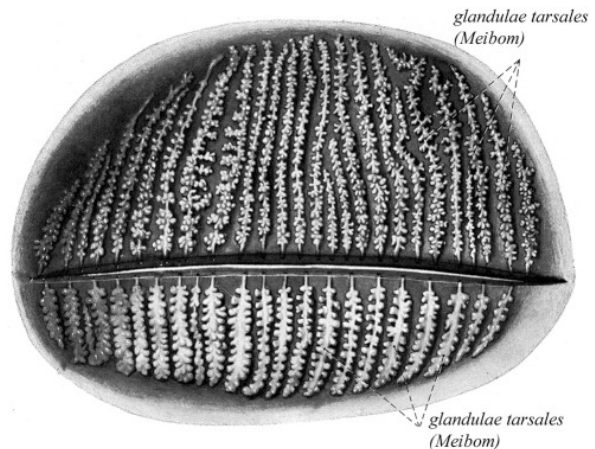
Dry Eye Disease

- Symptoms vs. signs
 - Lack of correlation of signs and symptoms (Nichols et al, 2004)
- Etiology
 - Evaporative (86% of dry eye patients, Lemp et al, 2012)
 - Aqueous deficient
 - Combination



Meibomian Glands

- Sebaceous glands that secrete the lipid layer of the tear film
- Total number
 - Number in upper eyelid: 25-40
 - Number in lower eyelid: 20-30
- Delivery of meibum through blinking forces



Meibomian Gland Atrophy in CL Wearers

Contact Lens Wear Is Associated with Decrease of Meibomian Glands

Reiko Arita, MD, PhD,^{1,2} Kouzo Itoh, MD, PhD,¹ Kenji Inoue, MD, PhD,³ Aya Kuchiba, PhD,⁴ Takuhiro Yamaguchi, PhD,⁵ Shiro Amano, MD, PhD²

Purpose: Approximately 30% to 50% of contact lens (CL) wearers report dry eye symptoms. Meibomian gland dysfunction has been recognized as a possible cause of CL-related dry eye. This study investigated the influence of CL wear on the meibomian glands using a newly developed meibographic technique.

Design: Cross-sectional observational case series.

Participants: Contact lens wearers (n = 121; 47 men, 74 women; mean age±standard deviation, 31.8±8.0 years) and healthy volunteers (n = 137; 71 men, 66 women; mean age±standard deviation, 31.4±15.1 years).

Methods: The following tests were performed: slit-lamp examinations of the eyelids, corneal and conjunctival staining using fluorescein, measurement of the tear film breakup time, evaluation of the meibomian glands using noncontact meibography, and measurement of tear production using the Schirmer I test. Partial or complete loss of the meibomian glands was scored for each eyelid using 4 grades (meiboscores): grade 0 (no loss of meibomian glands) through grade 3 (the area characterized by gland dropout was more than 66% of the total area containing the meibomian glands). The meiboscores for the upper and lower eyelids were summed for each subject.

Main Outcome Measures: Score of meibomian gland changes (meiboscore), tear film breakup time, and Schirmer test value.

Results: The meiboscore was significantly higher ($P<0.0001$) in CL wearers (mean, 1.72; 95% confidence interval, 1.47–1.96) than in the control group (mean, 0.96; 95% confidence interval, 0.73–1.19). The average meiboscore of CL wearers was similar to that of a 60- to 69-year-old age group from the normal population. A significant positive correlation was observed between the duration of CL wear and the meiboscore.

Conclusions: Contact lens wear is associated with a decrease in the number of functional meibomian glands. This decrease is proportional to the duration of CL wear.

Financial Disclosure(s): Proprietary or commercial disclosure may be found after the references. *Ophthalmology* 2009;116:379–384 © 2009 by the American Academy of Ophthalmology.

Table 1. Mean Meiboscores in Contact Lens Wearers and Nonwearers

	Mean Meiboscore (95% Confidence Interval)		
	Contact Lens Wearers	Nonwearers	P Value
Total	1.72 (1.47–1.96)	0.96 (0.73–1.19)	<0.0001
Upper eyelid	0.86 (0.71–1.01)	0.32 (0.24–0.40)	<0.0001
Lower eyelid	0.87 (0.68–1.05)	0.62 (0.48–0.76)	0.036

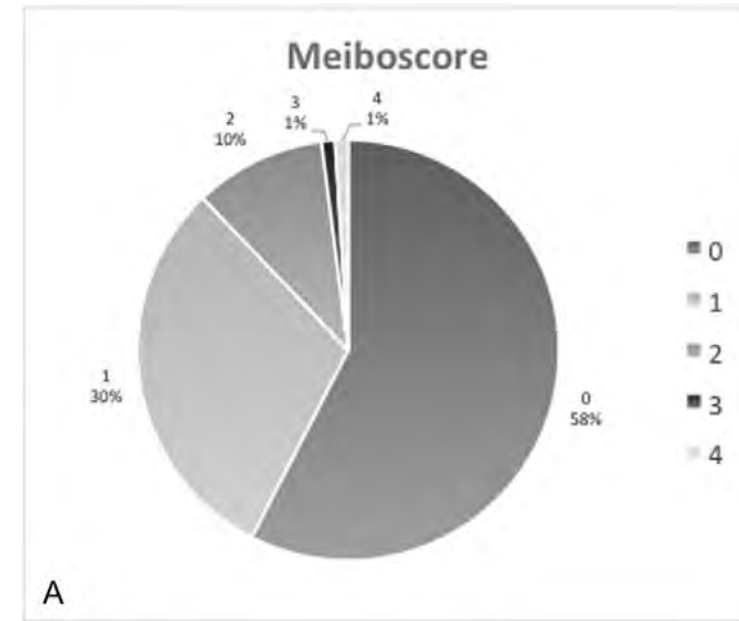
Meibomian Gland Atrophy in Children



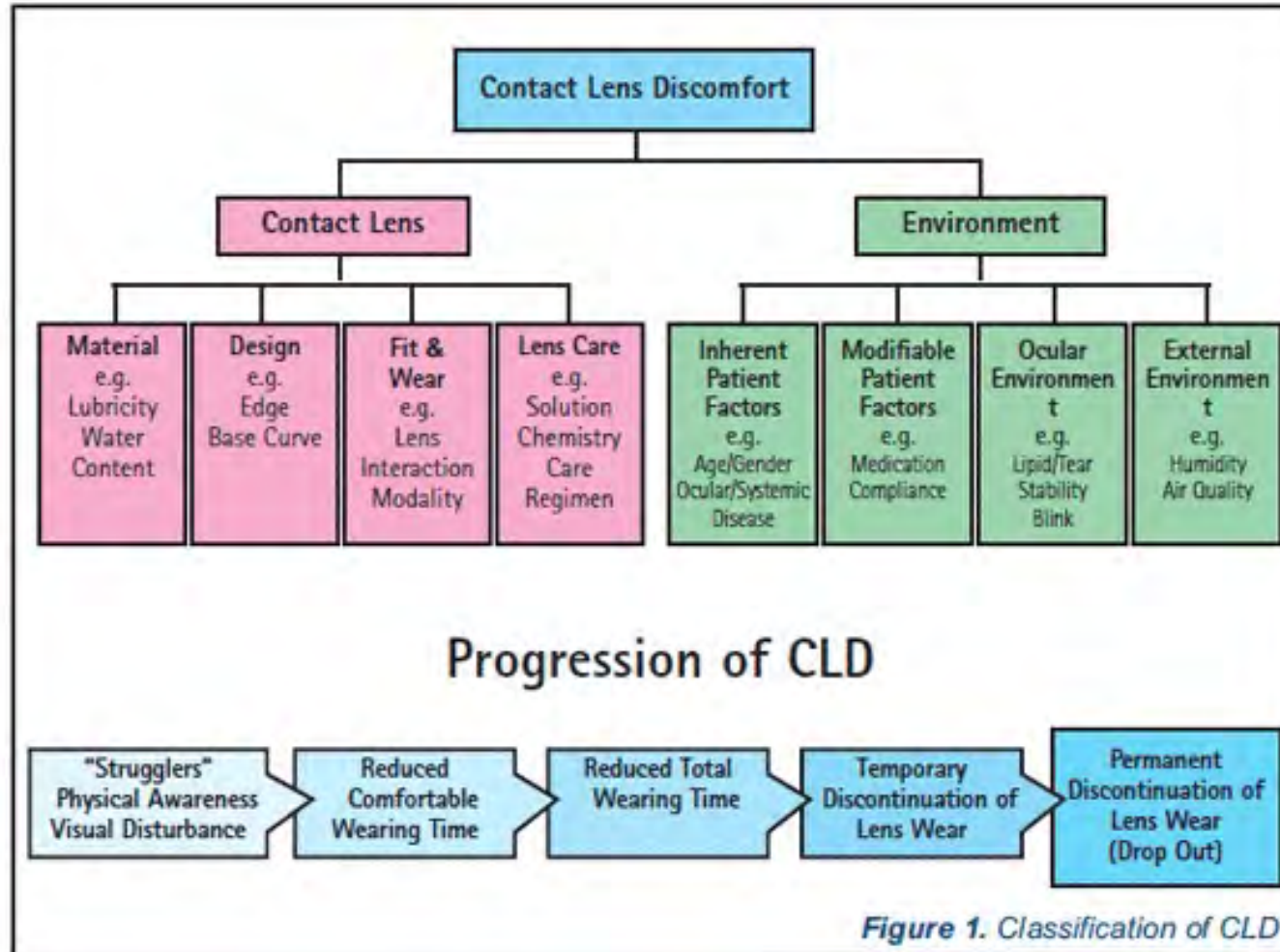
A: Meiboscore = 0

B: Meiboscore = 2

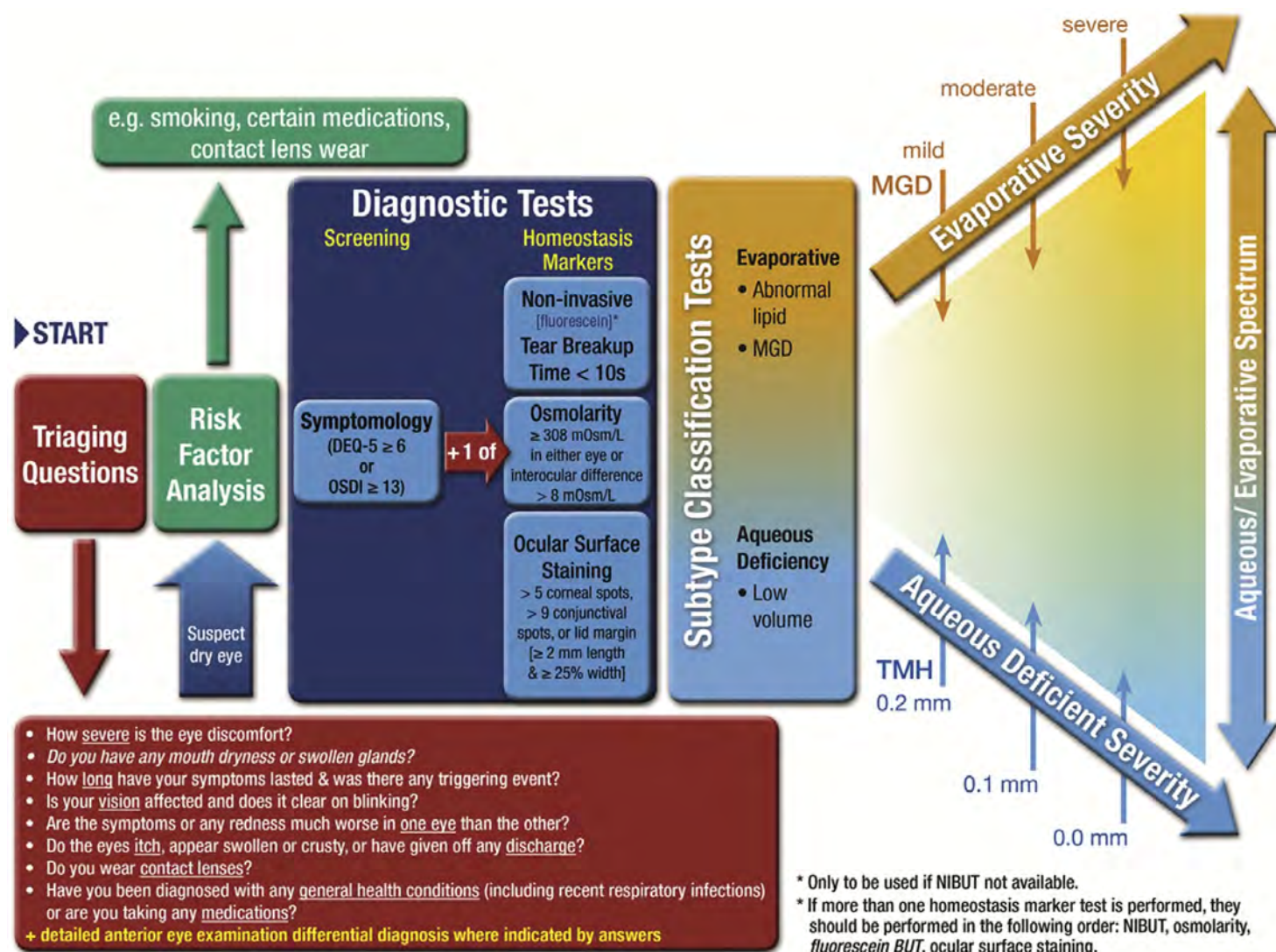
C: Meiboscore = 4



Contact Lens Discomfort



Diagnostic Approach



Purpose of the Study

- To understand the ocular surface measurements between children and adults as it was hypothesized children would have better quality tear films and ocular surfaces than adults
- Use results for future targeted treatments to improve the contact lens-related comfort in adults.

Methods

- Inclusion criteria:
 - 7-17 year old and 22-40 year old soft contact lens wearers
 - At least 6 hours/day 2 days/week for no more than 16 years
 - No current use of any ocular medication except artificial tears
 - No presence of any ocular condition that would affect visual performance
 - No presence of any systemic condition that may cause dry eye disease
 - No history of any ocular surgery
 - Not currently pregnant or breastfeeding
 - No change in or initiation of any systemic medications in the past 30 days

Methods

- Measurements conducted while wearing habitual contact lenses:
 - Contact lens history (years of lens wear, hours/day, and days/week)
 - Electronic device usage (hours/day)
 - Questionnaires
 - Contact Lens Dry Eye Questionnaire-8 (CLDEQ-8)
 - Ocular Surface Disease Index (OSDI)
 - National Eye Institute Refractive Error Quality of Life Instrument-42 (NEI RQL-42)
 - High and low contrast LogMAR visual acuity OD, OS, and OU
 - Contact lens fit assessment (movement, centration, wettability, deposits)
 - Slit lamp examination
 - Bulbar and limbal conjunctival hyperemia

Contact Lens Dry Eye Questionnaire-8 (CLDEQ-8)

CONTACT LENS QUESTIONNAIRE-8 (CLDEQ-8)

1. Questions about **EYE DISCOMFORT**:

- a. During a typical day in the past 2 weeks, **how often** did your eyes feel discomfort while wearing your contact lenses?

0 Never
1 Rarely
2 Sometimes
3 Frequently
4 Constantly

When your eyes felt discomfort with your contact lenses, **how intense was this feeling of discomfort...**

- b. At the end of your wearing time?

Never have it	Not at All Intense				Very Intense
0	1	2	3	4	5

2. Questions about **EYE DRYNESS**:

- a. During a typical day in the past 2 weeks, **how often** did your eyes feel dry?

0 Never
1 Rarely
2 Sometimes
3 Frequently
4 Constantly

When your eyes felt dry, **how intense was this feeling of dryness...**

- b. At the end of your wearing time?

Never have it	Not at All Intense				Very Intense
0	1	2	3	4	5

Patient/Subject #: _____

Date: __/__/__ Time: _____

3. Questions about **CHANGEABLE, BLURRY VISION**:

- a. During a typical day in the past 2 weeks, **how often** did your vision change between clear and blurry or foggy while wearing your contact lenses?

0 Never
1 Rarely
2 Sometimes
3 Frequently
4 Constantly

When your vision was blurry, **how noticeable was the changeable, blurry, or foggy vision ...**

- b. At the end of your wearing time?

Never have it	Not at All Intense				Very Intense
0	1	2	3	4	5

4. Question about **CLOSING YOUR EYES**:

During a typical day in the past 2 weeks, **how often** did your **eyes bother you so much that you wanted to close them?**

0 Never
1 Rarely
2 Sometimes
3 Frequently
4 Constantly

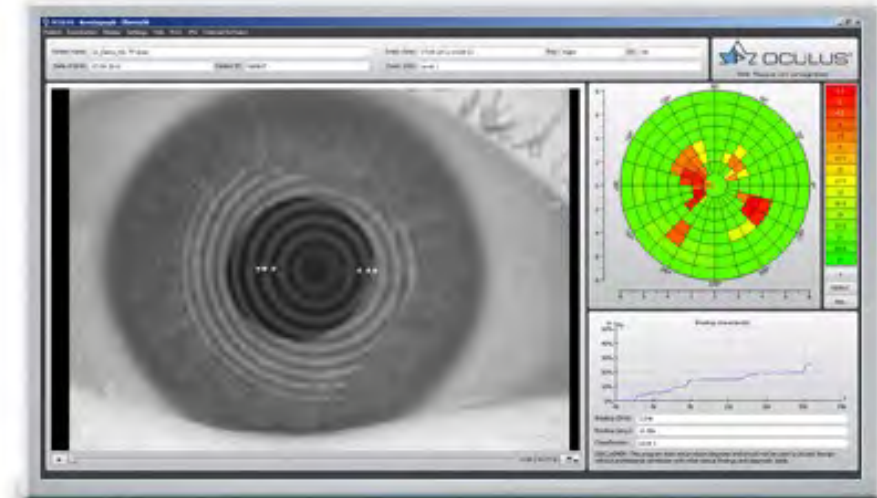
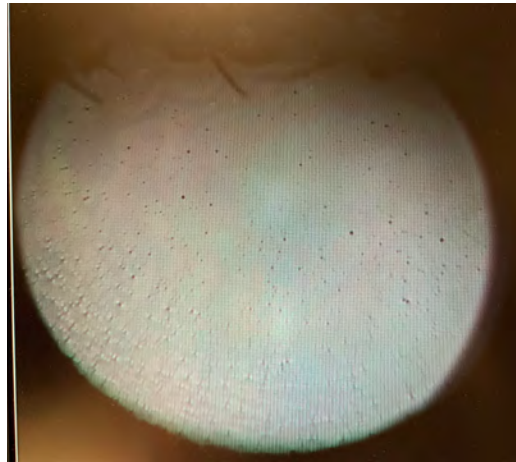
5. Question about **REMOVING YOUR LENSES**:

How often during the past 2 weeks, did your eyes *bother you so much* while wearing your contact lenses that you felt as if you needed to stop whatever you were doing and **take out your contact lenses?**

1 Never
2 Less than once a week
3 Weekly
4 Several times a week
5 Daily
6 Several times a day

Methods

- Measurements conducted while wearing habitual contact lenses:
 - Pre-lens lipid layer thickness OD, OS
 - Inferior tear meniscus height OD, OS
 - Pre-lens Non-Invasive Keratograph Break-Up Time (NIKBT) OD, OS
 - Tear osmolarity OD, OS
 - Tear sample collection OD, OS



Methods

- Measurements conducted while not wearing habitual contact lenses:
 - Lipid layer thickness OD, OS
 - Phenol red thread test OD, OS
 - Non-Invasive Keratograph Break-Up Time (NIBUT) OD, OS
 - Meibomian gland expression OD, OS
 - Meibography
 - Slit lamp examination
 - Conjunctival staining OD, OS using lissamine green
 - Corneal staining OD, OS using sodium fluorescein
 - Lid wiper staining OD, OS using lissamine green
 - Eyelid, conjunctiva, and cornea assessment

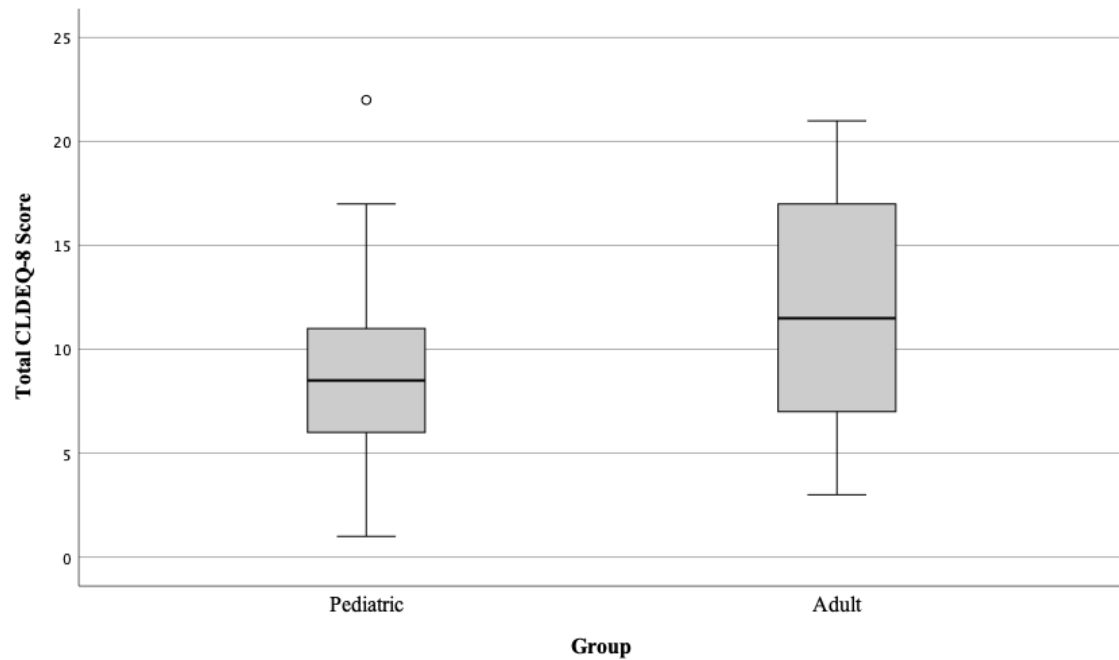


Results: Demographic Information

	Pediatric (n=30)	Adult (n=30)
Age (years)	14.1 ± 2.2	25.6 ± 3.1
Female (%)	60.0	56.7
Ethnicity (% Non-Hispanic or Latino)	96.7	100.0
Race (%)		
Caucasian	80.0	76.7
African American	3.3	3.3
Native Hawaiian or other Pacific Islander	0.0	0.0
Asian	16.7	16.6
Other	0.0	3.3

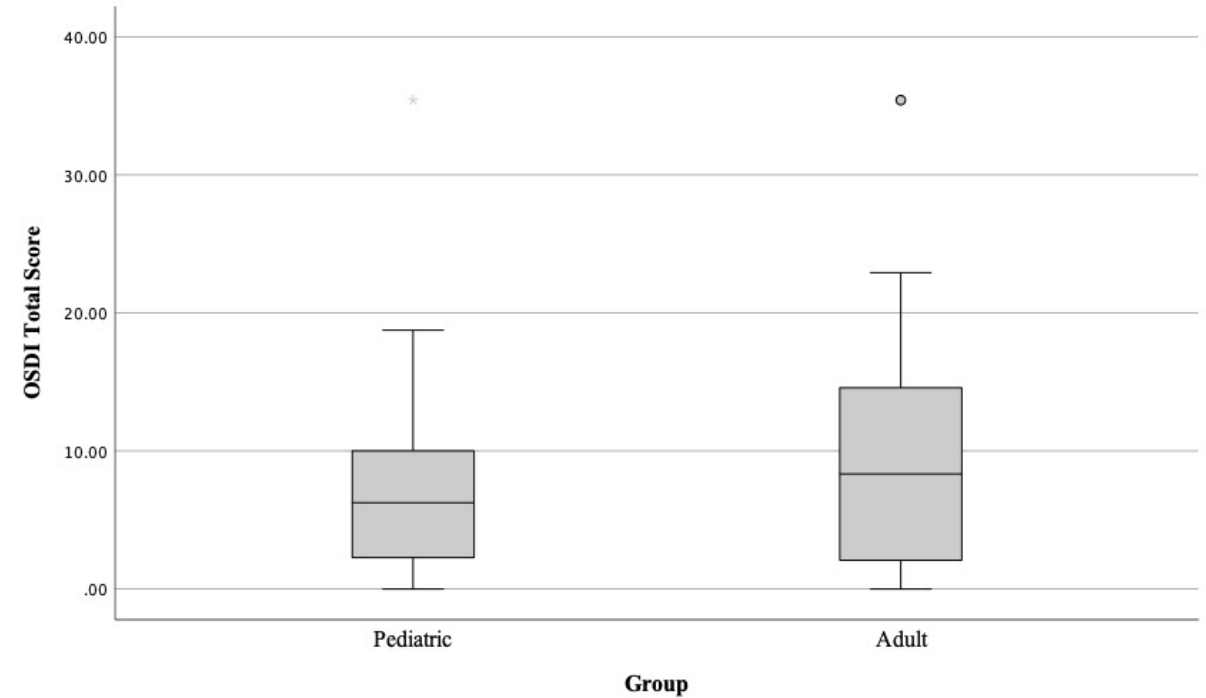
Questionnaire Scores

CLDEQ-8



- 25% of children symptomatic
- 50% of adults symptomatic

OSDI



- 17% children symptomatic
- 27% adults symptomatic

Results

	Pediatric	Adult	P-value
Overall score	81.3 (12.2)	83.9 (13.5)	0.290
Subscales			
Clarity of vision	89.6 (31.8)	91.67 (20.8)	0.413
Expectations	50.0 (31)	25.0 (50)	0.094
Near vision	96.9 (13.0)	100 (6.3)	0.067
Far vision	60.0 (6.7)	95.0 (12.1)	<0.001
Diurnal fluctuations	93.8 (18.8)	87.5 (12.5)	0.849
Activity limitations	100.0 (1.6)	100.0 (0.0)	0.984
Glare	100.0 (25.0)	87.5 (25.0)	0.334
Symptoms	92.9 (15.2)	75.0 (25.0)	0.002
Dependence on Correction	50.0 (28.1)	66.7 (15.6)	<0.001
Worry	75.0 (28.1)	75.0 (25.0)	0.336
Suboptimal correction	100.0 (0.0)	100.0 (3.1)	0.005
Appearance	100.0 (6.7)	100.0 (6.7)	0.357
Satisfaction with Correction	90.0 (20.0)	80.0 (20.0)	0.067

NEI-RQL-42

	Pediatric	Adult	P-value
LogMAR distance HCVA OD	+0.00 ± 0.09	-0.05 ± 0.09	0.019
LogMAR distance HCVA OS	+0.00 ± 0.08	-0.03 ± 0.07	0.048
LogMAR distance HCVA OU	-0.05 ± 0.07	-0.10 ± 0.04	0.002
LogMAR distance LCVA OD	+0.19 ± 0.14	+0.11 ± 0.09	0.013
LogMAR distance LCVA OS	+0.21 ± 0.12	+0.12 ± 0.06	<0.001
LogMAR distance LCVA OU	+0.11 ± 0.10	+0.04 ± 0.07	0.002

LogMAR visual acuity

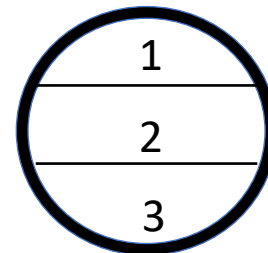
Lipid Layer Thickness

	Pediatric	Adult	P-value
Segment 1 OD (nm)	24.1 ± 10.7	24.4 ± 11.3	0.659
Segment 1 OS (nm)	23.1 ± 10.33	20.4 ± 9.8	
Segment 2 OD (nm)	27.6 ± 11.0	28.7 ± 12.7	0.709
Segment 2 OS (nm)	28.0 ± 10.6	24.5 ± 11.2	
Segment 3 OD (nm)	27.8 ± 8.5	28.3 ± 7.9	0.554
Segment 3 OS (nm)	29.0 ± 6.9	24.7 ± 7.0	
Segment 0 OD (nm)	27.9 ± 11.2	28.3 ± 12.6	0.831
Segment 0 OS (nm)	28.1 ± 10.8	24.7 ± 11.99	

Pre-lens lipid layer thickness

	Pediatric	Adult	P-value
Segment 1 OD (nm)	30.7 ± 11.5	25.5 ± 10.6	0.035
Segment 1 OS (nm)	33.1 ± 12.5	27.1 ± 11.5	
Segment 2 OD (nm)	35.1 ± 12.4	29.9 ± 11.7	0.037
Segment 2 OS (nm)	39.3 ± 13.0	31.9 ± 12.3	
Segment 3 OD (nm)	36.5 ± 9.4	30.0 ± 8.0	0.017
Segment 3 OS (nm)	40.6 ± 10.2	32.7 ± 7.6	
Segment 0 OD (nm)	35.6 ± 12.3	29.8 ± 12.0	0.022
Segment 0 OS (nm)	39.6 ± 13.4	31.6 ± 12.5	

Bare eye lipid layer thickness



Lipid Layer Thickness

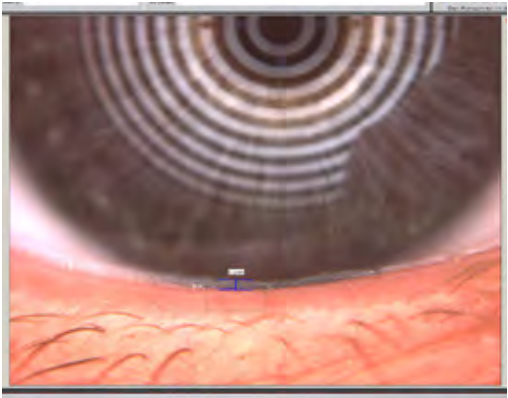
	Without CL lipid layer thickness - With CL lipid layer thickness	P-value
Pediatric		
OD		
Segment 0 (nm)	7.6 ± 13.0	0.008
Segment 1 (nm)	6.8 ± 12.5	0.012
Segment 2 (nm)	7.5 ± 11.9	0.004
Segment 3 (nm)	9.6 ± 10.5	0.003
OS		
Segment 0 (nm)	9.6 ± 10.5	<0.001
Segment 1 (nm)	8.5 ± 10.1	<0.001
Segment 2 (nm)	9.2 ± 11.0	<0.001
Segment 3 (nm)	9.7 ± 11.8	<0.001
Adult		
OD		
Segment 0 (nm)	2.1 ± 10.8	0.360
Segment 1 (nm)	2.2 ± 12.1	0.412
Segment 2 (nm)	1.9 ± 11.3	0.432
Segment 3 (nm)	2.3 ± 8.2	0.195
OS		
Segment 0 (nm)	6.8 ± 16.6	0.103
Segment 1 (nm)	6.9 ± 15.2	0.071
Segment 2 (nm)	7.2 ± 16.3	0.078
Segment 3 (nm)	8.1 ± 19.1	0.091

Results

	Pediatric	Adult	P-value		Pediatric	Adult	P-value
Tear osmolarity OD (mOsm/L)	297 ± 14	297 ± 9	0.208	Average tear meniscus height OD (mm)	0.18 ± 0.03	0.20 ± 0.04	0.057
Tear osmolarity OS (mOsm/L)	296 ± 13	303 ± 11		Average tear meniscus height OS (mm)	0.17 ± 0.04	0.19 ± 0.04	



Tear Osmolarity



Tear Meniscus Height

Non-Invasive Keratograph Break-Up Time

	Pediatric	Adult	P-value
Average first pre-lens tear break-up time OD (seconds)	10.67 ± 5.18	8.89 ± 5.31	0.061
Average first pre-lens tear break-up time OS (seconds)	9.71 ± 4.42	7.76 ± 2.98	
Average of the average pre-lens tear break-up time OD (seconds)	15.65 ± 3.70	15.13 ± 4.06	0.349
Average of the average pre-lens tear break-up time OS (seconds)	15.43 ± 3.83	14.40 ± 3.54	

Pre-lens

	Pediatric	Adult	P-value
Average first tear break-up time OD (seconds)	12.19 ± 6.04	10.22 ± 5.72	0.216
Average first tear break-up time OS (seconds)	11.73 ± 6.34	10.00 ± 6.05	
Average of the average tear break-up time OD (seconds)	14.66 ± 5.98	12.61 ± 5.76	0.254
Average of the average tear break-up time OS (seconds)	14.34 ± 6.05	12.80 ± 5.82	

Bare eye

Tear Sample Analysis

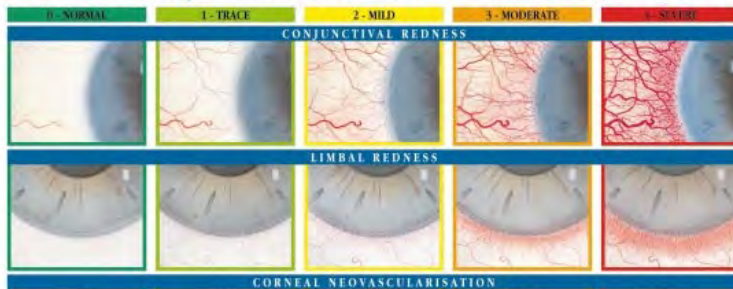
Cytokine	Pediatric	Adult	P-value
EGF	109.1 (445.7)	147.6 (337.4)	0.495
EGFR	2209.0 (19376.4)	4395.1 (38113.4)	0.246
Eotaxin	0 (6782.7)	1430.9 (6297.9)	0.412
G-CSF	0 (925.8)	0.0 (2716.8)	0.645
GRO	0 (0.0)	219.2 (8027.7)	0.039
HB-EGF	0.0 (15110.5)	2257.1 (12402.8)	0.398
ICAM-1	4648.1 (44077.0)	11021.7 (29764.5)	0.338
IFN- γ	0.0 (0.0)	0.0 (0.0)	0.790
IL-1 α	0.0 (1304.7)	555.9 (1361.7)	0.461
IL-1 β	0.0 (745.1)	0.0 (839.4)	0.805
IL-1Ra	25916.2 (20961.1)	30591.4 (11348.8)	0.115
IL-2	0.0 (0)	0.0 (0.0)	0.919
IL-4	179.2 (542.6)	199.9 (574.6)	0.815
IL-5	0 (1752.8)	0.0 (1058.6)	0.603
IL-6	0 (831.6)	244.0 (910.4)	0.275
IL-6R	322.3 (5743.7)	1618.1 (6144.8)	0.047
IL-7	0.0 (0.0)	0.0 (0.0)	0.651
IL-8	64.9 (349.1)	256.6 (426.6)	0.186
IL-10	0.0 (548.0)	0.0 (0.0)	0.544
IL-11	0.0 (0.0)	0.0 (0.0)	0.297

Cytokine	Pediatric	Adult	P-value
IL-12 p40	0.0 (1454.8)	0.0 (917.6)	0.512
IL-12 p70	0.0 (201.0)	0.0 (131.3)	0.894
IL-13	0.0 (0.0)	0.0 (0.0)	0.771
IL-15	0.0 (485.0)	0.0 (373.3)	0.917
IL-16	963.9 (6362.0)	1977.7 (6151.7)	0.205
IL-17	0.0 (0.0)	0.0 (0.0)	0.605
IP-10	20306.7 (31484.0)	19641.6 (23685.2)	0.797
Lipocalin-2 (NGAL)	113414.0 (36402.3)	114957.3 (31523.6)	0.219
MCP-1 (CCL2)	0.0 (598.7)	0.0 (222.7)	1.000
MIG (CXCL9)	1905.6 (9864.6)	1446.3 (5588.7)	0.469
MIP-1 α (CCL3)	0.0 (2256.0)	161.2 (9692.1)	0.177
MIP-1 β (CCL4)	0.0 (108.7)	70.5 (159.8)	0.127
MIP-1 δ (CCL15)	0 (3121.4)	0.0 (2394.9)	0.835
MMP-9	670.5 (13589.9)	5925.2 (9767.7)	0.132
RANTES (CCL2)	0 (34.4)	0.0 (152.2)	0.390
TGF β -1	130624.1 (1827444.1)	476817.3 (2635727.8)	0.215
TIMP-1	177390.3 (53079.9)	194960.9 (30386.5)	0.036
TIMP-2	160349.0 (43769.8)	157680.1 (17492.1)	0.808
TNF- α	0.0 (2308.5)	0.0 (1760.1)	0.928
VEGF-A	0 (318.9)	0.0 (347.5)	0.852

Slit Lamp Examination

- No significant differences observed with conjunctival hyperemia, corneal and conjunctival staining, and lid wiper epitheliopathy

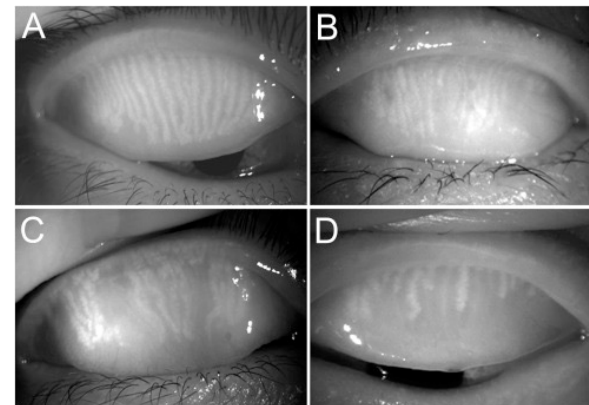
Efron Grading Scales for Contact Lens Complications



Meibography

	Pediatric	Adult	P-value
Meiboscore upper eyelid OD	1 (1)	1 (1)	0.186
Meiboscore upper eyelid OS	1 (0.5)	1 (1)	
Meiboscore lower eyelid OD	1 (1)	1 (1)	0.468
Meiboscore lower eyelid OS	1 (0)	1 (1)	

Grade	% loss of meibomian gland area
0	0
1	<1/3
2	1/3 – 2/3
3	>2/3



Conclusion

- 25% of pediatric participants had symptomatic CLDEQ-8 scores compared to 50% of adults
 - Previous study found 4% of children were symptomatic (Greiner and Walline, 2010)
- Ocular surface measurements in children and adults were more similar than hypothesized
 - Differences were observed in logMAR HCVA OU and LCVA OU and lipid layer thickness

Conclusion

- Bare eye lipid layer thickness was greater in pediatric group
 - Treatments targeted to increase production and quality of lipid layer
- Children need to be evaluated for dry eye disease
 - Children may complain less than adults
 - Possible reasons for dry eye in children (digital device use, nutrition, contact lens wear, etc.)

Thank you!

Katherine Bickle
kbickle12@yahoo.com