Tear exchange and epithelium in extended wear

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Principal properties of new silicone hydrogel contact lenses

	PureVision (Balafilcon A)	Focus Night and Day (Lotrafilcon A)
Dk/t (cm x mlO_2) (S x ml x mmHg)	110 x 10-9	175 x 10-9
Water Content	35%	24%
Centre thickness	0.09 mm.	0.08 mm.
Modulus	**1.1 Mpa**	**1.2 MPa**

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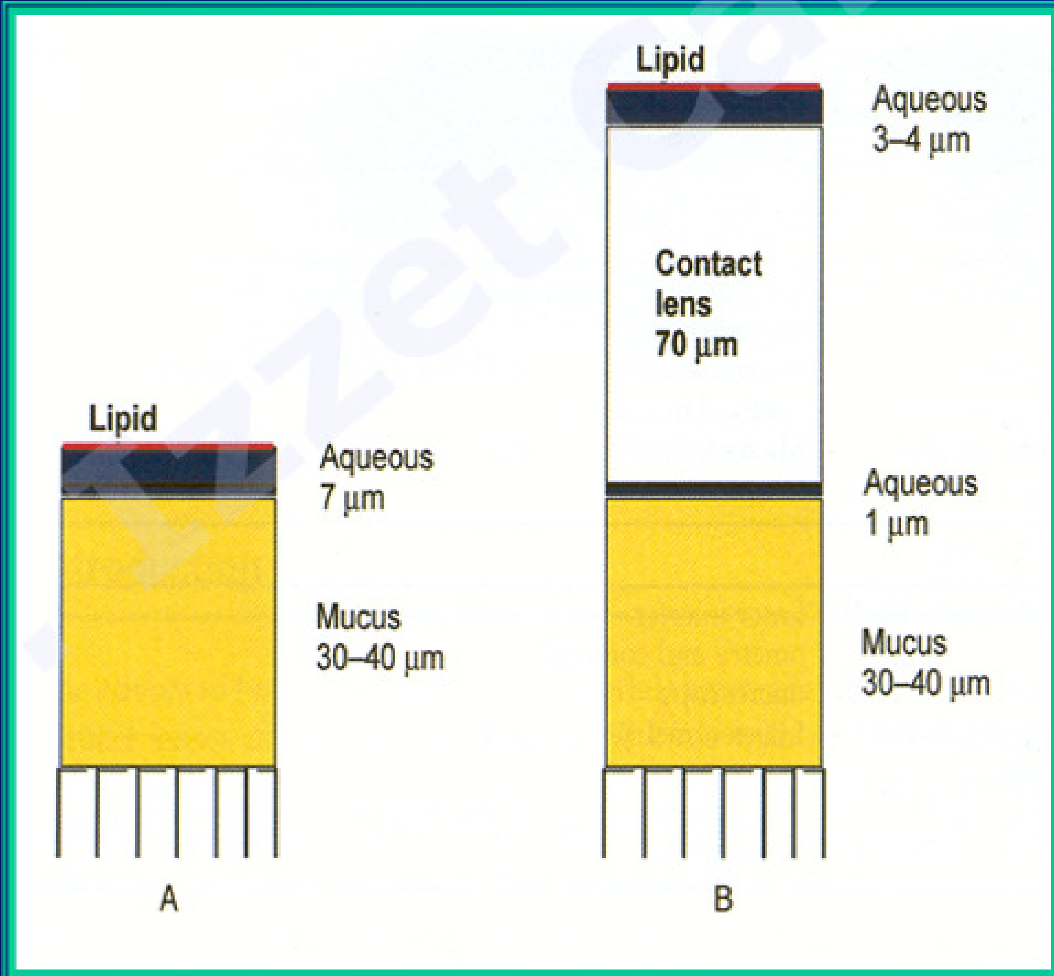
Pre-lens tear film

- Lipid layer
- Aqueous layer

Post-lens tear film

- Aqueous layer
- Mucin layer



Bruce AS and Brennan NA. *Cont. Lens* 1988; 15: 304-9..

Aqueous phase

- During closed eye, it becomes depleted / 180 minutes
- Upon eye opening, it replenishes / 30 minutes.

- Different hydrogel materials produce different aqueous phase profiles.

Low modulus, mid-water content materials ➲ Uniform
High modulus, low-water content materials ➲ Uneven

- It is essential for elimination of back surface debris.

Bruce AS and Brennan NA. *Cont. Lens* 1988; 15: 304-9.
Faber et al. *Optom. Vis. Sci*. 1991; 68: 380-4..
Bruce AS and Brennan NA. *Clin. Eye Vis. Care* 1992; 4: 111-6.
Little SA and Bruce AS. *Ophthalmol. Phsiol. Opt.* 1994; 14: 65-9.
Little SA and Bruce AS. *Int. Cont. Lens Clin.* 1995; 22: 148-24.

Mucin phase

•Pressure buffer from external mechanical pressure for the corneal and conjunctival epithelia.

Kaura R, Tiffany J. In the *Precorneal Tear Film.* 1986; 728-32.
Dilly PN. In the *Lacrimal gland, Tear film and and Dry eye Syndromes* 2 1994; 239-47.

What is the modulus of rigidity?

It is the measurement of the resistance to deformation of a material under compression.

Material	W.C.	Modulus
Etafilcon A	55%	0.26 mN/m^2
Crofilcon A	38%	0.94 mN/m^2
Lotrafilcon A	24%	1.2 mN/m^2
Balafilcon A	35%	1.1 mN/m^2

Stevenson RWW. In *Contact Lens Practice.* 1994; 71-82.
Tighe BJ. In *Contact Lenses.* 1997; 50-92.

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What may be the clinical results of this condition?

High rigidity lenses

- mould incompletely to the cornea
- aqueous phase of variable thickness
- variable squeeze pressure on the mucin phase
- more efficient at converting the eye-lid force into lens movement

What is the modulus of elasticity?

It is the measurement of the resistance to deformation of a material under tension.

We can expect the silicone hydrogels to be more elastomeric than any conventional hydrogel materials.

Kikkawa Y. In *Contact Lens Practice.* 1994; 113-22.
Tighe BJ. In *Contact Lenses.* 1997; 50-92

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Clinical results of the high elasticity

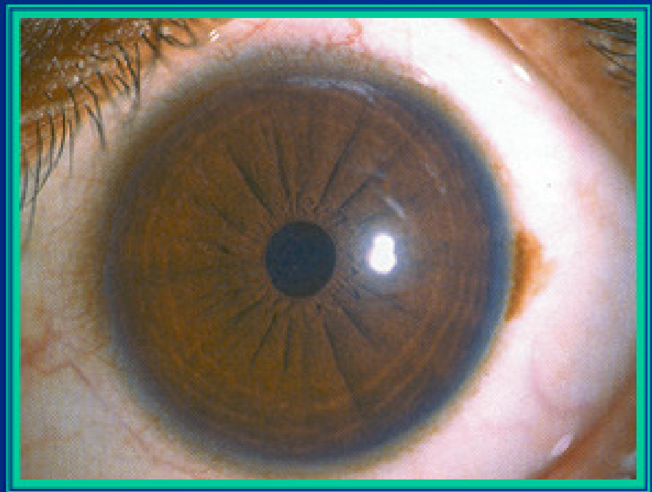
- Upon eye opening , rapid recentration and a strong repetitive squeeze pressure

- During closed eye wear, the eye-lid exerts a constant pressure that stretches the lens, particularly during lens decentration associated with REM phase of sleep.

Combine effects of lens rigidity and elasticity

- repeated high levels of localized pressure and erosion of the mucin gel
- epithelial damage and lens binding with high friction
- mucin balls

- superior epithelial arcuate lesions (SEAL)



Doshi S. *Optician.* 1999; 217: 20-1.
Watanabe K. In *Current Opinions in the Kyoto Cornea Club* 1999; Vol III.

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Tear exchange

During sleep

- tear film viscosity increases
- aqueous production stops
- increase in the concentration of inflammatory proteins and cells

Upon waking

- aqueous production starts
- tear film viscosity decreases
- lens movement takes places at blink producing aqueous in and out flow under the CL promoting the elimination of inflammatory proteins and cells.

Josephson JE and Caffery BE. *Int. Cont. Lens Clin.* 1979; 6: 223-42.
Mertz GW and Holden BA. *Can J Optom.*. 1981; 43: 203-5.

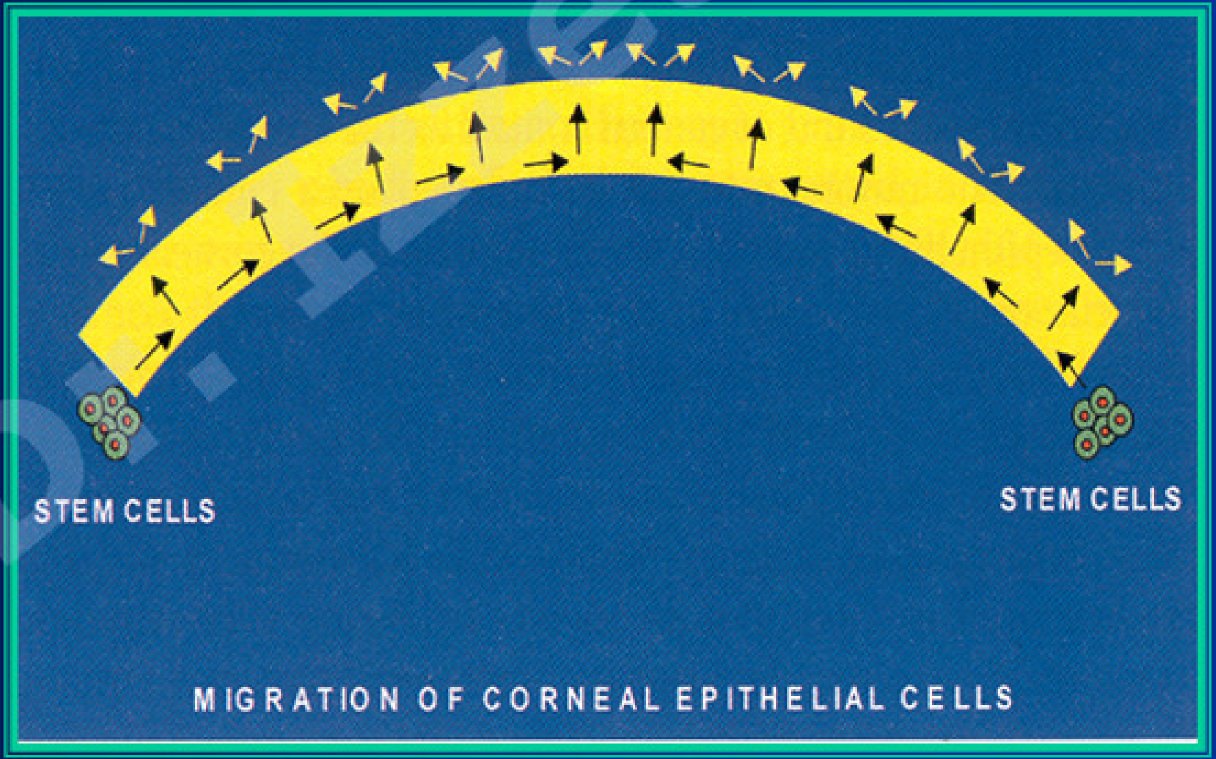
Results of fluorometric measurements about aqueous phase exchange

- tear exchange, varying from 0.6 % to 1.2% per blink.
- No effect was found changing contact lens type or altering lens fit for conventional hydrogels.
- Lens diameter was found to be an important factor.

Polse KA. *Invest Ophthalmol Vis Sci.* 1979; 18: 409-13.
McNamara et al. *Optom Vis Sci*. 1998; 75: 316-22.

Corneal epithelium

1. Mitosis
2. Migration
3. Differentiation
4. Cell shedding



Auran et al. *Ophthalmology*. 1995; 102: 33-41.

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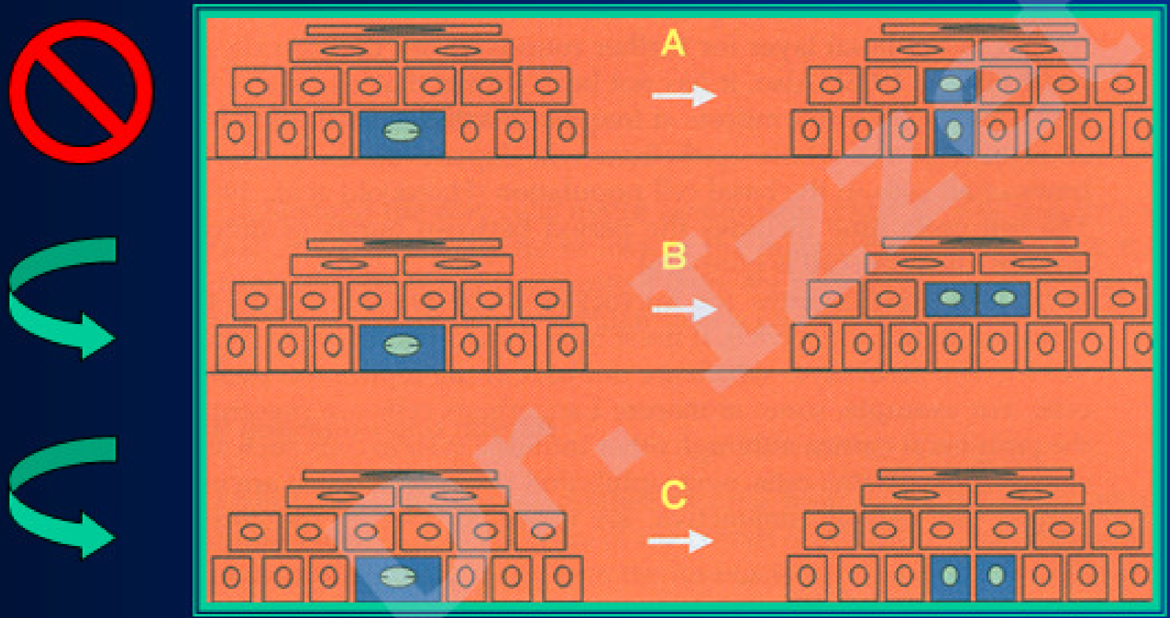
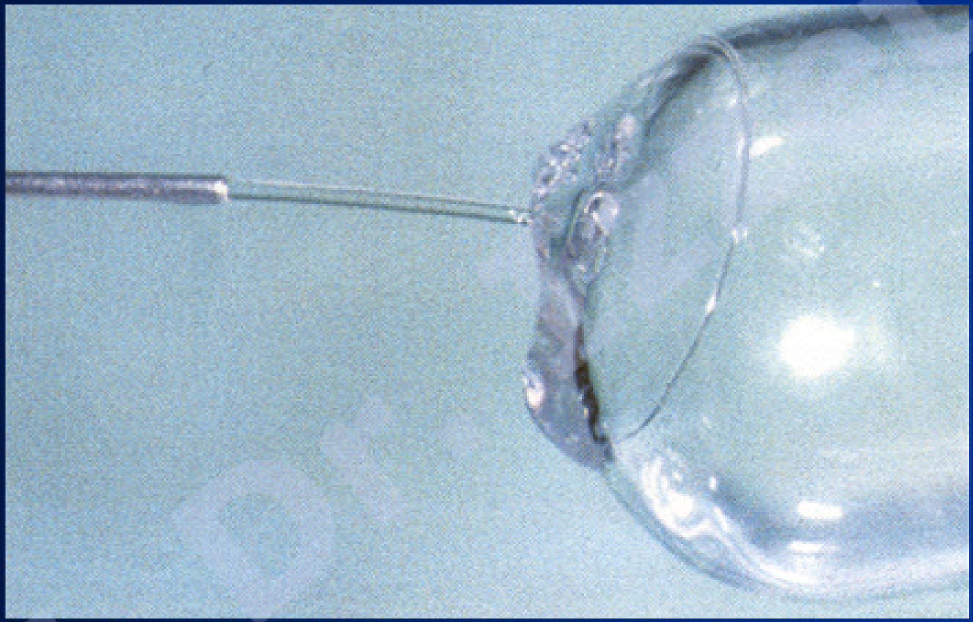
Cell shedding



Beebe DC and Masters B. *Invest Ophthalmol Vis Sci.* 1996; 37: 1815-25.

Contact lens cytology and surface cell types



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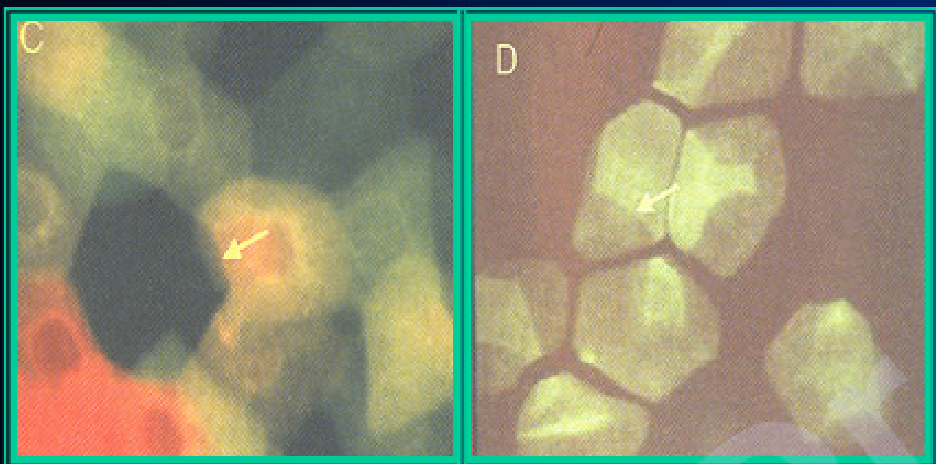
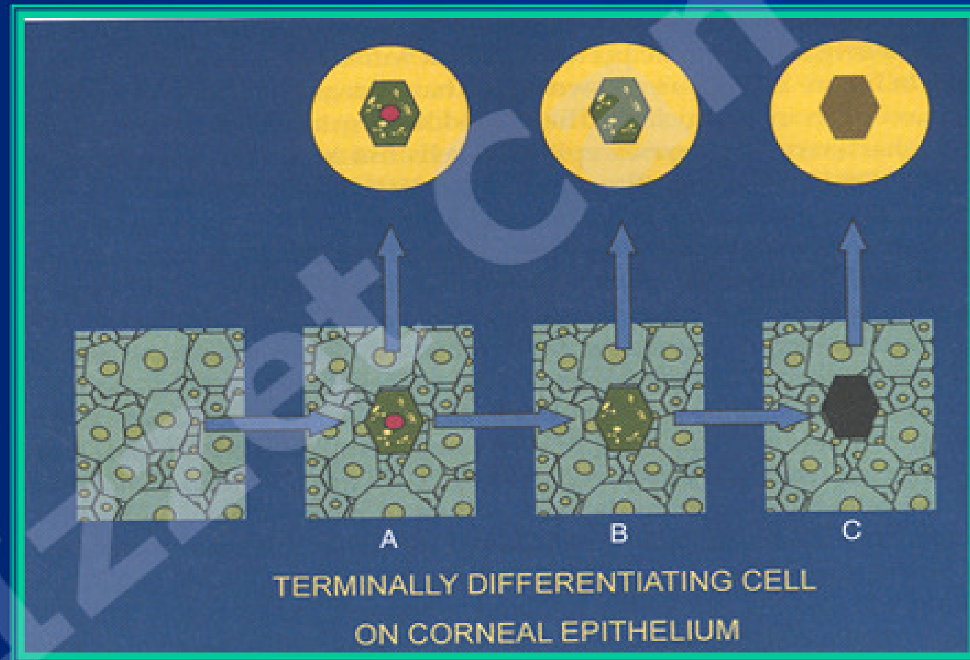
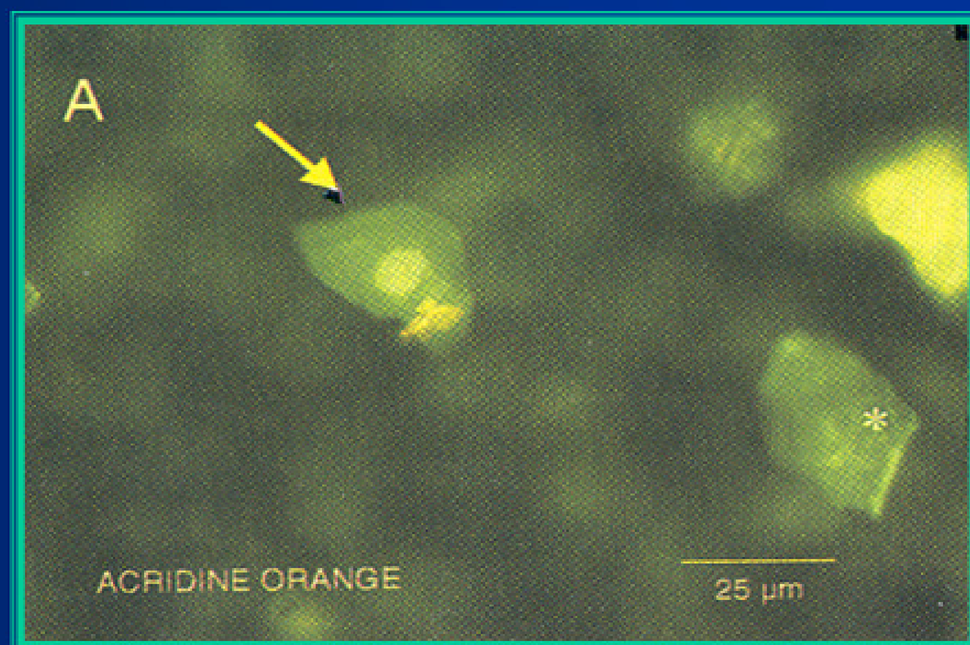
Cell shedding



Cell ghosts





Estil S and Wilson G. *Invest Ophthalmol Vis Sci.* 1998; 39: 201.

- mean cell area : 355-850 μm^2
- mean cell lenght : 20-75 μm

- There is a decrease in cell size when the relative percentage of dead cells increases.

- In extended wear, the size of corneal surface cells increases with the wearing time.

- It has been found that EW does cause an increase in permiability barrier.

Nelson et al. *Arch Ophthalmol.* 1983; 101: 1869-72.
Barr JT and Testa LM. *Int. Cont. Lens Clin.* 1994; 21 : 105-11.
Lohman LE et al. *Ophthalmology* 1982; 89: 621 - 9.
Laurent J and Wilson G. *Optom Vis Sci.* 1997; 74. 280 -7.
Jester et al. *Invest Ophthalmol Vis Sci.* 1998: 39: 922 - 36.
Tsubota et al. *Br J Ophthalmol* 1996; 80: 144 -7.
McNamara et al. *Ophthalmology* 1998; 105: 2330-5.

Factors which affect the shedding rate

1. Osmolality
2. Hypoxia
3. Toxic exposure
4. Small ions
5. Shear forces
6. Tear replenishment

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Factors which affect the shedding rate

1. Osmolality
2. Hypoxia
3. Toxic exposure
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6. Tear replenishment

- Very high and very low osmolality increases the shedding rate

Wilson G. *Cornea* 1996; 15. 229-34.

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Factors which affect the shedding rate

1. Osmolality
2. Hypoxia
3. Toxic exposure
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- Reduce the shedding rate
- Affects the epithelial thickness
- Affects the mitotic rate

Wilson G. *Curr Eye Res* 1994; 13: 409-13.
Ren et al. *J Cont Lens Assoc Ophthalmol* 1999; 25: 80-100.
Cavanagh HD. *Invest Ophthalmol Vis Sci*. 1998: 39: 337.
Hamano et al. *Jpn J Ophthalmol 1983; 27: 451 -8.*

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Factors which affect the shedding rate

1. Osmolality
2. Hypoxia
3. Toxic exposure
4. Small ions
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6. Tear replenishment

•Benzalkonium chloride and surfactants increase the shedding rate.

Ren H and Wilson G. *Acta Ophthalmol*. 1994: 72: 447 - 52.

Factors which affect the shedding rate

1. Osmolality
2. Hypoxia
3. Toxic exposure
4. Small ions
5. Shear forces
6. Tear replenishment

- Potassium and calcium could increase the shedding rates.

Bachman W and Wilson G. *Invest Ophthalmol Vis Sci*. 1985; 26: 1484 -8.

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Factors which affect the shedding rate

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•It is known that the shear force of the lids during blinking is the main factor outside the epithelium.

•Overnight CL wearing might be effective in reducing the shedding rate by protecting from the lid shear forces and by cancelling the CL removing.

Ren H and Wilson G. *Curr Eye Res*. 1996: 15: 1054 -9.
Wilson G and Laurent. In *Lacrimal Gland, Tearfilm and Dry eye Syndromes 2* 1998; 675-81.

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Factors which affect the shedding rate

1. Osmolality
2. Hypoxia
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6. Tear replenishment

- Cells accumulate beneath the lens, as a result of the relatively low rate of tear exchange.

McNamara et al. *Optom Vis Sci* 1998; 75: 316-22.

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Conjunctival epithelium

Changes in the bulbar conjunctiva

- increased keratinization
- snake-shaped nuclear material
- increased inflammatory cells
- reduced nucleus to cytoplasm ratios
- squamous metaplasia

Aragona et al. *Eye* 1998; 12: 461-6.

- **Is the epithelium compromised in some way by a slowing down in shedding and mitosis? The epithelium appears to be capable of regulating cell productioin and loss under a variety of conditions. Is EW one of these conditions?**

Wilson G. In *Silicone Hydrogels* 2000; 22-44.

- **Is stagnation beneath the lens a problem? Does stasis beneath the lens make the epithelium more vulnerable to infection?**

Wilson G. In *Silicone Hydrogels* 2000; 22-44.

- **Should tear exchange beneath a lens be decreased? if binding of bacteria to cells under a lens is a problem, would it be useful to reduce the access of bacteria by limiting tear exchange? The lens could be inserted under near-sterile conditions which would be maintained under the lens until it is removed. Until the mechanism of microbial keratitis is understood at a very basic level we cannot develop a rational approach to its prevention.**

Wilson G. In *Silicone Hydrogels* 2000; 22-44.

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- **Should tear exchange beneath a lens be increased? if mucus from goblet cells is an important part of the protective mechanism of the pre-corneal tears, will the susceptibility to infections be increased by the prolonged functional isolation of the corneal epithelium in EW?**
  More exchange would allow more mucus and immune system components under the lens and more flushing of cellular debris and bacteria.

Wilson G. In *Silicone Hydrogels* 2000; 22-44.

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