Efficacy of Multi-Purpose Contact Lens Solutions on Passive Lysozyme Removal from Silicone Hydrogel and Conventional Hydrogel Contact Lenses

F. Zhang [1,2], M-A Glasier [1], H. Sheardown [2], L. Corstorphine [2], L. Jones [1,2]

1.Centre for Contact Lens Research, School of Optometry, University of Waterloo, Ontario, Canada

2. Dept of Chemical Engineering, McMaster University, Hamilton, Ontario, Canada

Introduction

- Protein deposition from tear film components is a major contribution to hydrogel contact lens spoilation.[1] These deposits adversely affect comfort, vision, and result in ocular complications such as giant papillary conjunctivitis. [2]
- Lysozyme plays a dominant role in protein deposition on conventional hydrogel (CH) contact lenses. [3] However, silicone hydrogel (SH) lenses adsorb considerably less lysozyme than conventional hydrogel lenses. [4]
- Current multi-purpose care regimens are typically used in a "no-rub" format, where lenses are placed in the regimen overnight, with no physical rubbing of the lenses being employed.
- The majority of available regimens were developed for conventional lens materials and have been formulated to optimize protein removal, frequently including components such as citric acid and Hydranate® (hydroxyalkylphosphonate).
- To-date, very little data exists on the ability of current care regimens to passively remove lysozyme from SH materials.

Purpose

- To evaluate the ability of 6 "no-rub" multipurpose solutions to passively remove lysozyme from silicone hydrogel (SH) and conventional hydrogel (CH) contact lens materials, using a radiotracer technique. [5]

Materials & Methods

- Regimens: Alcon OptiFree® Express® (OFX), AMO Complete® Moisture Plus™ (COM), B&L ReNu® MoistureLoc™ (RML), B&L ReNu MultiPlus® (RMP), CIBA Aquify™ (AQ), and CIBA ClearCare® (CC).

Regimens	Principal Components
Alcon OptiFree® Express®	0.001% polyquad (polyquaternium-1), sodium citrate (citric acid), boric acid, sorbitol, sodium chloride, EDTA, 0.0005% MAPD (Aldox), poloxamine (Tetronic 1304)
AMO Complete® Moisture Plus™	0.0001% polyhexanide (polyaminopropyl biguanide), phosphate buffer, sodium chloride, propylene glycol, HPMC, EDTA, taurine, poloxamer 237
ReNu® MoistureLoc™	0.00045% alexidine, boric acid, sodium chloride, sodium phosphate, poloxamine (Tetronic 1107), poloxamer 407, polyquaternium-10, Hydranate (hydroxyalkylphosphonate)
ReNu MultiPlus®	0.0001% polyhexanide (polyaminopropyl biguanide), boric acid, sodium chloride, sodium borate, poloxamine (Tetronic 1107), EDTA, Hydranate (hydroxyalkylphosphonate)
CIBA Aquify™	0.001% polyhexanide (polyaminopropyl biguanide), dexpanthenol, sorbitol, sodium phosphate, tromethamine, poloxamer 407, EDTA
CIBA ClearCare®	3% hydrogen peroxide, phosphate buffer, sodium chloride, Pluronic 17R4

- 4 SH materials (balafilcon, galyfilcon, lotrafilcon A and lotrafilcon B) and 4 CH materials (polymacon, omafilcon, alphafilcon and etafilcon).
- The concentration of lysozyme for soaking lenses was 2.0 mg/ml. Time periods to soak lenses were 24 hours, 3 days and 3 weeks.
- Artificial lysozyme solution was prepared at the final concentration of 2.0 mg/ml in 10-mM phosphate buffered saline, pH 7.4. ^{125}I-Lysozyme was diluted by unlabeled lysozyme solution to a gamma counting rate of 10^6 CPM/ml.
- Lenses were soaked in brown glass vials containing 1.5 ml of lysozyme solution at 37°C with constant rotation. Following incubation, lenses were rinsed in PBS briefly before soaking statically for 8 hours in lens cases containing 3ml or in polypropylene tubes with 15ml of each care regimen, at room temperature. After passive cleaning, lenses were removed from the regimens without rinsing in the saline. Cleaned lenses and soaking regimens were measured separately for gamma radioactivity (Beckman Gamma 5500).
- The calculation of % cleaning efficacy is the ratio of gamma counting remaining on each lens to total amount of counting (lens plus regimen), multiplied by 100%.
- All data were reported as mean and standard deviation bars. One-way ANOVA and multiple comparison tests were run. A p value of < 0.05 indicated a significant difference.

Results

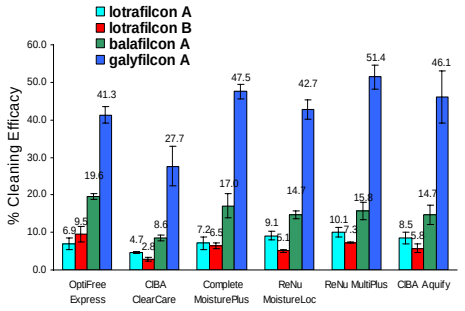

Figure 1: Cleaning Efficacy of All Regimens on SH Contact Lenses after 3 Weeks Soaking.

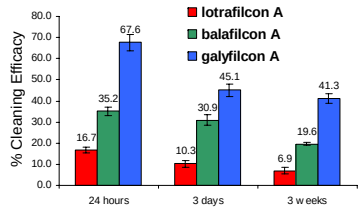

Figure 2: Cleaning Efficacy of OptiFree Express on SH Contact Lenses after Various Periods of Soaking.

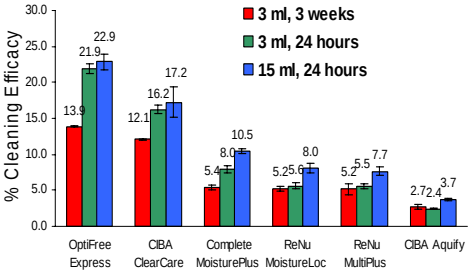

Figure 3: Cleaning Efficacy of All Regimens on Etafilcon after Various Periods of Soaking.

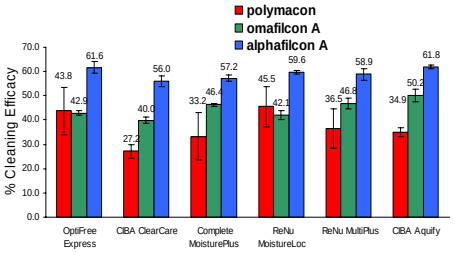

Figure 4: Cleaning Efficacy of All Regimens on CH Contact Lenses after 3 Weeks Soaking.

- Fig 1 shows that among SH's, galyfilcon exhibited the highest cleaning efficacy of around 40%, compared to below 20% for other SH lenses ($p<0.01$).
- Fig 2 shows that cleaning efficacy decreased with increased soaking time ($p<0.01$), possibly due to an increased amount of denatured lysozyme being deposited on the lens surfaces.
- Fig 3 indicates that a citrate-containing solution (OptiFree Express) provided the highest cleaning efficacy for etafilcon ($p<0.01$), in agreement with previous work.[6] A peroxide-based system (ClearCare) also performed well. ($p<0.01$).
- Fig 4 shows that the cleaning efficacies on CH lenses found using this technique is very consistent with a previous report. [7]
- The cleaning efficacy depended on the material-regimen combination under test:
  - Etafilcon exhibited the greatest variation between care regimens (OFX ~25% to Aquify <5%; $p<0.01$).
  - For the other CH materials no difference was found between care regimens (polymacon ~35%, omafilcon ~40% and alphafilcon ~55%; p=NS).
  - Cleaning efficacy with SH materials did vary between materials: galyfilcon had ~30-50% efficacy vs the other SH materials, with ~5-20% efficacy ($p<0.01$).

Conclusions

Using a radiotracer technique, we were able to directly measure the amount of lysozyme remaining on lens materials after exposure to a variety of care regimens. For CH materials, etafilcon was most influenced by the care regimen composition. For SH materials, galyfilcon was most easily cleaned, possibly due to its hydrophilic lens surface treatment (HydraClear™), which is PVP-based..

References

1. Bontempo AR, Rapp J. Protein and lipid deposition onto hydrophilic contact lenses in vivo. *CLAO J* 2001; 27: 75-80.
2. Meisler DM, Keller WB: Contact lens type, material, and deposits and giant papillary conjunctivitis. *CLAO J* 1995; 21: 77-80.
3. Sack R *et al*. Specificity and biological activity of the protein deposited on the hydrogel surface. *Invest Ophthalmol Vis Sci* 1987; 28: 842-849.
4. Jones L *et al*. Lysozyme and lipid deposition on silicone-hydrogel lens materials. *Eye and Contact Lens* 2003 (suppl); 29: s75 – s79.
5. Chen H *et al*. Surface properties of PEO-silicone composites: reducing protein adsorption. *J Biomater Sci Polym Ed* 2005;16:531-48.
6. Hong BS *et al*. Cleaning capability of citrate-containing vs non-citrate contact lens cleaning solutions: an in vitro comparative study. *ICLC* 1994; 21: 237-240.
7. Franklin V. Cleaning efficacy of single-purpose surfactant cleaners and multi-purpose solutions. *Contact Lens and Anterior Eye* 1997; 20:63-68

Acknowledgements

This work was supported by a collaborative grant between Alcon Research Ltd and NSERC Canada and grants from the Canada Foundation for Innovation, and University of Waterloo Graduate Studies Office.