Contact Lenses in 2020 and Beyond: What Does the Future for Contacts Look Like?

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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
• Inflamax Research
• Johnson & Johnson Vision
• Menicon
• Nature’s Way
• Novartis
• SafiLens
• Santen
• Shire
• SightGlass
• Visioneering

Detection of Ocular Disease

The Future?

Summary

Renewable future uses of contact lenses, Optom Vis Sci April 2016

Wearable Sensor Market

• Market for wearable technology is expected to reach $US 31.27 Billion by 2020, at annual growth rate of 17.8%
  – smartwatches
  – wristbands
• Major players
  – Adidas, Apple, Fitbit, Garmin, Google, Nike, Samsung, Sony
Clothing?

NetFit has created "smart" socks that sense when you fall asleep and pause the show you're watching.

"Smart" CL System

Technology Overview

Smart Contact lens
- Sensor
- Bluetooth
- Contact lens

RF Reader
- RF reader
- Bluetooth reader

Software
- App
- Android
- iOS

J&J; Samsung; Sony; Medella Health

>100 patents since 2012

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

FDA Approval: March 2016

Biosensing Contacts

FDA grants marketing approval for Triggerfish IOP monitoring device

ANALYZE BIOSENSOR
- Monitor contact lens
- Measure pressure
- Transmit data

TRANSDUCER
- Convert pressure
- Convert data

MEASURABLE SIGNAL
- Output signal
- Display data

Mansouri, & Weinreb (2012). Continuous 24-hour intraocular pressure monitoring for glaucoma--time for a paradigm change. Swiss Med Wkly, 142, w13545.


Contact Lenses for Detection of Diabetes?

- 382 million diabetics worldwide
- Daily monitoring of blood glucose is intrusive
  - diabetic patient pricks their finger 1800 times a year
- Different body fluid such as urine, saliva or tears could be monitored
- The glucose monitoring devices market is expected to be more than $20 billion by the end of 2020
- Tears are easily accessible
  - but takes more than 10 mins to collect enough tears in a capillary tube to test

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 the time due to technical limitations

Verily (Google Life Sciences): 2013 - 2018

- 2013: Google announces its entry into the market.
- 2014: Partners with Novartis
- 2018: Project halted

Potential CL Biosensor Targets

- **Ocular**
  - IOP
  - osmolarity
  - biomarkers
  - dry eye disease etc
- **Systemic**
  - diabetes
  - cancer markers
  - blood pressure
  - neurological disorders
  - heart rate
  - kidney function
  - ovulation

Topical Drops

- >95% of current market for disease management
  - poor insertion technique in >50%
  - over-slip
  - poor compliance in 50%
  - rapid tear flow drainage
  - drug diluted by blinking
  - Substantial systemic absorption
  - <5% of drug gets to target

Management of Ocular Disease
Tear Meniscus Height (35µl Drop Size)

What about using CL?

- Soaked CL should release drugs much slower
- First suggested in original Wichterle hydrogel patents in 1960’s
  - First published manuscript in 1971
- 93% of surveyed clinicians would be interested in using a drug delivering bandage CL
- Clinical success depends on
  - Drug loading
  - Drug release
  - Affinity between drug and material

Soaked CL should release drugs much slower

What diseases may be relevant?

A Dream?

Plenty of recent interest...

Ophthalmic Drug Delivery

PubMed search: “drug delivery” + “contact lens” = 344

1. Wichterle & Lim. Cross-linked hydrophilic polymers and articles made therefrom. US patent: 3220960; 1965
Long-Term Therapy

- Glaucoma
- Allergy

Microbial Keratitis

Severe Corneal Abrasions

Management of Severe Abrasions

What Drugs are Being Used with Bandage Contact Lenses?

<table>
<thead>
<tr>
<th>Type</th>
<th>Patients Treated (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antibiotic</td>
<td>47.5</td>
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<tr>
<td>Steroid periocularly</td>
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<tr>
<td>Nonsteroidal anti-inflammatory</td>
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<tr>
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<tr>
<td>Glaucosma</td>
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</tr>
<tr>
<td>Unspecified</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Why not just use existing commercial lenses?
Topical Drugs & CL Materials

CORE – published 10 papers on this topic

Release Rates


Soft Lens Drug Delivering Concepts


Molecular Imprinting


Clinically Relevant Amounts of Release up to 14 days


Drugs Under Investigation

- Anti-infective
- Anti-inflammatory
- Anti-glaucoma
- Epidermal growth factor
- Anti-allergy
  - J&J have already evaluated and reported on 4 trials of a ketoti fen-releasing DD lens (2007-2015)
  - antihistamine/mast cell stabilizer
Visual Augmentation

- Contact lens is a key component
  - permits focus on content close to the eye
  - or carries the information display

Mission Impossible: Ghost Protocol
Unique Optical Opportunities

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

Summary

- Contact lens industry is alive and well
- Practitioners now have MANY excellent products to offer to patients
- Contacts will still be here in 2050!
- Development of new products with
  - extended roles in
    - health monitoring
    - health treatment
    - unique optical uses

THANK YOU