Although not yet commercially available in the United States, and with many prototypes still in preclinical study stages, drug-eluting contact lenses may pave the way for a new era of eye care. This article offers a brief overview of the technology and what lenses are in the pipeline.

LENS PROS AND CONS
As with all things in life, there are pros and cons to drug-eluting contact lenses. Let’s start with the less positive aspects of this treatment modality.

Drawbacks
Disadvantages to drug-eluting contact lenses include risk of corneal toxicity with long-term wear and discontinuation of wear due to lens discomfort. There are also fears that unhygienic lens handling may lead to infection. Issues remain with lens preparation and storage; for example, the fast and simple soaking method of drug loading is limited by poor sustained medication release. Encouragingly, however, several lenses loaded via more complex methodologies allowing more gradual medication release recently moved into clinical studies. Given the inherent limitations associated with other methods of ocular drug delivery, the potential of drug-eluting lenses is likely not over-exaggerated.

Advantages
Drug-eluting contact lenses may improve patient compliance compared

AT A GLANCE

- Drug-eluting contact lenses may improve patient compliance and treatment efficacy compared with topical medications.
- Although no drug-eluting lenses are commercially available in the United States, several have received FDA approval or are in clinical trials.
with topical medication use, which is often limited by forgetfulness and poor hand-eye coordination. In a prospective study of patients with glaucoma, 29% could not administer drops into their eyes.

Reduced drop instillation ability may result in under- or overdosing, which can lead to side effects or treatment inefficacies if patients don’t follow the correct dispensing interval or quantity.

Contact lenses may also increase treatment efficacy by enhancing drug bioavailability. The medication is eluted into a post-lens tear layer that is partially shielded from blink-induced tear film turnover. This allows longer residence time on the ocular surface. It has been estimated that drug bioavailability from hydrogel contact lenses ranges from 35% to 50% versus a maximum of 5% from topical medication.

In addition, contact lenses may reduce the risk of side effects by lowering the required drug concentration and reducing systemic medication absorption. Because only 1% to 7% of topical medication is absorbed by the eye, the excess solution can induce periorbital side effects, such as hyperpigmentation of the periocular skin and periorcular fat atrophy in the case of prostaglandin analogues for glaucoma.

Soft contact lenses are also terminally sterilized, making preservatives unnecessary and lowering the risk of corneal and conjunctival epithelial toxicity.

**IN THE PIPELINE**

**LL-BMT1** (MediPrint Ophthalmics) is a 3D-printed lens that gradually releases nonpreserved bimatoprost (Table). It is intended to be worn continuously for 1 week. Less bimatoprost-associated hyperemia was observed with the lens versus topically. Phase 2 studies are underway to identify an optimal bimatoprost concentration for the lens. MediPrint’s lower-dose concentration, 26 µg, lowered IOP by an average of 5.5 mm Hg from baseline at week 3 (n = 11), compared with a 6.7 mm Hg IOP reduction via timolol 0.5% twice daily (n = 14). The company hopes its medium-dose concentration, 32 µg, will induce a larger drop in IOP. LL-BMT1 has been well tolerated thus far, with comfort scores further improving among patients as the study progresses.

MediPrint plans to offer plano and prescription lens options. Approval has been granted to begin clinical studies on the moxifloxacin-eluting lens, **MoxiLens** (Glint Pharmaceuticals), which is soaked in a 5 mg/mL moxifloxacin solution. The presence of vitamin E in the lens serves as a diffusion barrier, significantly delaying drug release.

The company is hopeful that the lens will ultimately be approved for up to 1 week of sustained release, and thus continuous wear time.

Sustained release of antimicrobials should yield extended therapeutic concentration exposure and reduce concentration troughs between drops. These troughs enable microbial proliferation and antibiotic resistance. Antibiotic-eluting lenses are also attractive for bandage and prophylactic purposes following corneal abrasion, erosion, or surgery.

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**TABLE.** Characteristics of FDA-Approved Drug-Eluting Contact Lenses and Those in Clinical Trials*

<table>
<thead>
<tr>
<th>LENS</th>
<th>LL-BMT1 (MediPrint Ophthalmics)</th>
<th>MoxiLens (Glint Pharmaceuticals)</th>
<th>TetraLens (TherOptix)</th>
<th>DexaLens (TherOptix)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEDICATION</td>
<td>Bimatoprost</td>
<td>Moxifloxacin</td>
<td>Tetracaine</td>
<td>Dexamethasone</td>
</tr>
<tr>
<td>PLANNED INDICATION</td>
<td>Mild to moderate open-angle glaucoma, ocular hypertension</td>
<td>Postsurgical, corneal abrasion/erosion</td>
<td>Postoperative pain (eg. photorefractive keratectomy)</td>
<td>Proliferative vitreoretinopathy</td>
</tr>
<tr>
<td>LENS MATERIAL</td>
<td>Undisclosed</td>
<td>Senofilcon A</td>
<td>Methafilcon A</td>
<td>Methafilcon A</td>
</tr>
<tr>
<td>DRUG LOADING METHOD</td>
<td>Digital 3D printing</td>
<td>Soaking, vitamin E slows diffusion</td>
<td>Drug loaded, film solvent casted</td>
<td>Drug loaded, film solvent casted</td>
</tr>
<tr>
<td>WEARING SCHEDULE</td>
<td>1 week (continuous)</td>
<td>1 week (continuous)</td>
<td>Undisclosed</td>
<td>Undisclosed</td>
</tr>
<tr>
<td>REFRACTIVE CORRECTION?</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>STAGE</td>
<td>Phase 2 clinical trials ongoing</td>
<td>Phase 1 clinical trials</td>
<td>Phase 1 clinical trials ongoing</td>
<td>Undisclosed</td>
</tr>
</tbody>
</table>

*Not an exhaustive list
The DexaLens (TherOptix) achieves sustained release by mixing dexamethasone into a poly(lactic-co-glycolic) acid film that serves as a barrier to drug diffusion. The film is encapsulated into the periphery of a methafilcon hydrogel contact lens with an optically clear central aperture. DexaLens resulted in significantly higher drug concentrations in the cornea versus topical dexamethasone. Rabbits wearing DexaLens also had retinal drug concentrations that were 200 times greater than hourly dosing with traditional bandage lenses. DexaLens demonstrated lower blood serum dexamethasone concentrations, indicating less systemic absorption compared with topical medication. If these findings are supported in humans, this option may enable less invasive medication delivery to the posterior segment than injections.

The TetraLens (TherOptix) contains tetracaine within a drug polymer peripheral ring designed identically to DexaLens. The drug load is less than five drops of tetracaine 1%. A non-peer-reviewed report of 20 post-photorefractive keratectomy patients in El Salvador showed no pain with TetraLens wear; significantly higher pain scores were reported in the contralateral eyes given traditional bandage lenses. Although the lens is still new to clinical studies of photorefractive keratectomy patients, it may also be useful after corneal crosslinking and corneal abrasions.

Of note, the Acuvue Theravision with Ketotifen product line (Johnson & Johnson MedTech Vision) has been discontinued globally and will not be launched commercially in the United States. This medication-releasing daily disposable contact lens is loaded with ketotifen via a soaking methodology and is indicated for patients who need vision correction and who have eye itch from allergies.

-looking ahead

Expect for companies to expand their medications offered once they have identified and tested a successful mechanism for drug loading and subsequent eluting via contact lenses. TherOptix has begun clinical studies with latanoprost using the same drug polymer film encapsulation technique and lens material described above. Glint Pharmaceuticals has several medications in the pipeline: bimatoprost, cysteamine, atropine, cyclosporine, and fortified antibiotics. All are expected to use vitamin E technology to provide sustained and gradual drug delivery. Drug-eluting contact lenses have the potential to revolutionize medical eye care, though we must be patient as adequately powered clinical studies are conducted.


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