Smart contact lenses: How far has glaucoma treatment gone?

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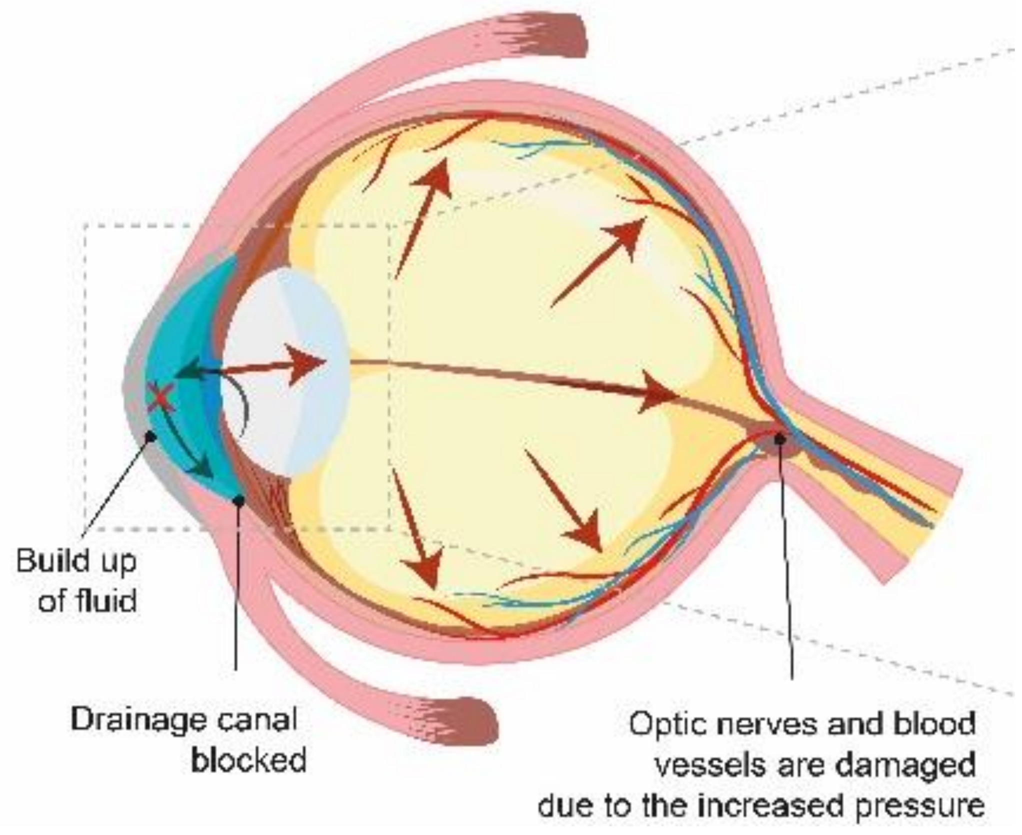
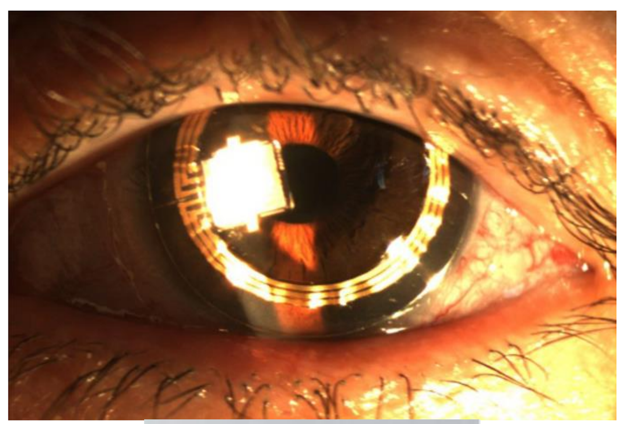
Introduction

Glaucoma, known as the "silent thief of vision", is the most common cause of treatable blindness worldwide, with a prevalence expected to be around 112.0 million by 2040 (Tham et al., 2014). Glaucoma is the common name for a group of progressive, neurodegenerative diseases caused in most cases by elevated intraocular pressure (IOP). IOP reduction is the primary goal of glaucoma treatment, as studies have shown that it can prevent the development and progression of glaucoma (Heijl et al., 2002). Treatment of glaucoma, like other chronic disorders, has two major drawbacks: first, there are the disadvantages of conventional ophthalmic dosage forms, such as low drug bioavailability and quick drainage due to lacrimation. The second issue is patients' non-adherence, which is primarily due to their forgetfulness (Kass et al., 2002).



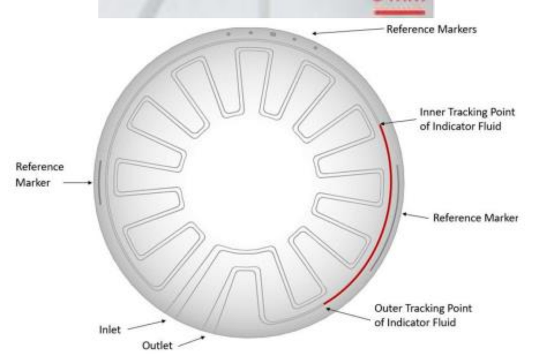
IOP monitoring Contact lenses (CLs)

Triggerfish®, commercially developed by SENSIMED was the first IOP monitoring CLs approved by European Regulatory Authorities in 2009 and by the FDA in 2016 (Chen et al., 2021). Triggerfish® is a device that combines smart CLs with electromechanical microsensor to detect spontaneous circumferential changes in the corneoscleral region (Dunbar et al., 2017).

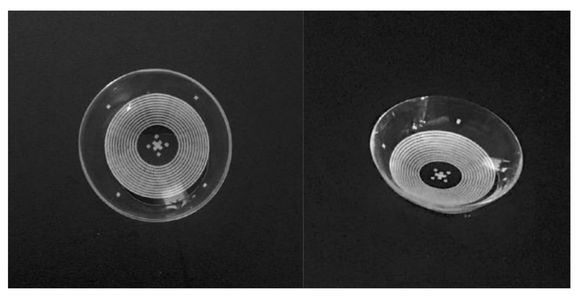


Pang et al. created CLs with a Wheatstone bridge circuit in 2019 to increase the detection of weak eyeball deformations, which is advantageous for high sensitivity and precision. A contact lens shape was created using a thermal model and then encased in a biocompatible polydimethylsiloxane (PDMS) layer (Pang et al., 2019).

Another idea is to use microfluidics in CLs to detect IOP. This device displays the changing volume of the microchannel as the fluid displaces in response to any volume change. Patients who are wearing these CLs will take pictures of them with their phones throughout the day (Campigotto et al., 2020).



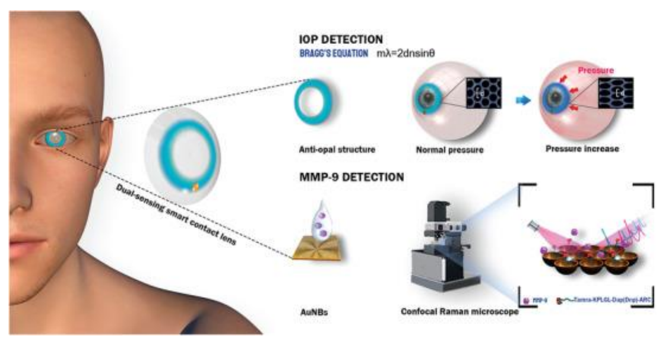
By superimposing a camera-captured image onto the micropattern of the contact lens using a computer-assisted virtual reference image, Lee et al. constructed CLs with moiré patterns of concentric circles that detected IOP changes. This device also allowed for the elution of integrated drug from a thermo-responsive nanogel drug carrier (Lee et al., 2020).



Kim et al. developed and tested a soft CLs for continuous IOP monitoring with a smartphone in volunteers (Kim et al., 2021).

Dou et al. designed a wearable CL IOP sensor based on a platinum strain gauge coated in a polyamide insulating layer and packaged in transparent PDMS using a micro-electro-mechanical method (Dou et al., 2021).

In addition to elevated IOP, it has been demonstrated that Matrix Metalloproteinease-9 (MMP-9) is overexpressed in glaucoma patients' tears. With this in mind, Ye et al. developed optical-based dual-function CLs for simultaneous detection of IOP and MMP-9. IOP is measured by changing the color of an antiopal structure, which eliminates the need for complicated electronics (Ye et al., 2022).



Conclusion

IOP elevation and variation are key risk factors of glaucoma progression. Concept behind employing CLs in IOP monitoring is that when IOP varies, so does eye curvature. Electronic parts make up most CLs, with detection software on computer or smartphone. However, most recent study is focused on finding way to avoid using electronics and instead employ less irritating approaches.

References

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