# Self-Tonometry in Glaucoma Management

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## Introduction

Intraocular pressure (IOP) is important for the diagnosis and management of glaucoma. However, office-based measurements do not show diurnal changes, spikes, effect of medications and compliance.

Patient-directed self-tonometry can be taken over 24 hours in a familiar environment without stress. Evidence suggests that 24-hour IOP monitoring changed management in 79.3% of cases.

## History

Self-tonometry evolved from the concept of continuous tonometry and assisted tonometry in the 19th century.

Continuous Tonometry, or "phasing", was first obtained by hospitalizing the patient for regular measurements over 24 hours. Other approaches included a tonometer that continuously indented the cornea (Maurice 1958), a wireless intraocular pressure-sensitive capacitor sensor (Collins 1967), and variations on continuous scleral applanation using a hydrogel ring (Couvillon et al 1976), a haptic contact lens (Cooper and Beale 1977, 1979), a suction cup (Nissen 1977, 1980) and a scleral buckle Wolbarsht et al 1980).

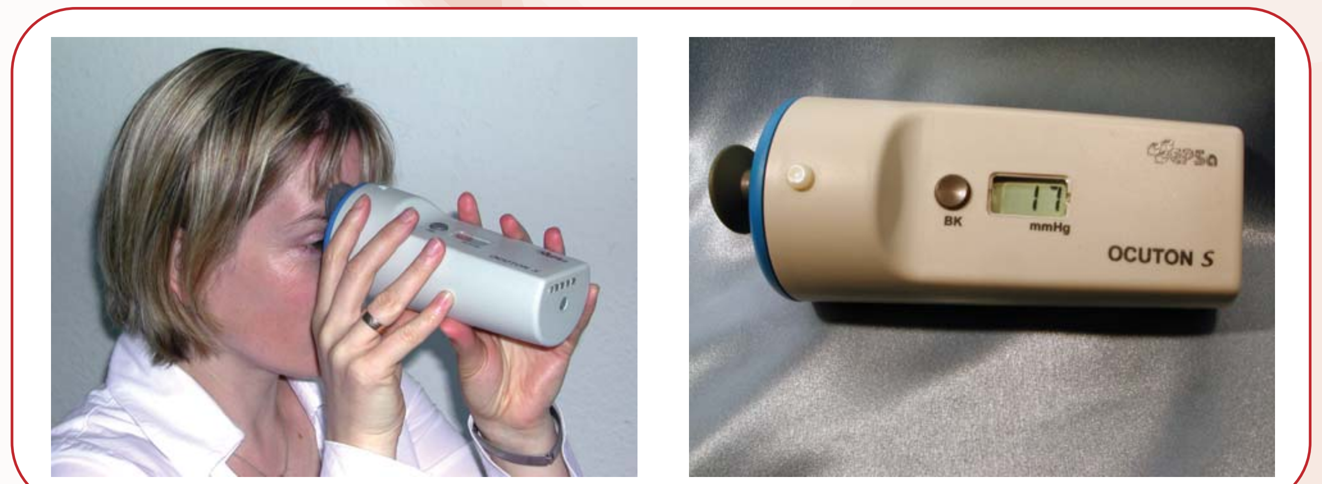
Assisted Tonometry where family and friends were recruited was examined by Posner (1965) on a modified Maklakoff tonometer, Jensen (1973) and Alpar (1983) on a Schiotz tonometer, and Stewart et al (1991) on an older model of the Pulsair-Keeler pneumatic tonometer.

Self-Tonometry was introduced by Zeimer, Wilensky et al in 1982 with the "Home-tonometer" using light beams and their refractive properties to automate alignment and applanation pressure. Boles Carenini et al (1992) also examined the older model Pulsair-Keeler tonometer for self-tonometry with limited success.

## Current Technology

### There are three self-tonometers commercially available today:

**Ocuton S** (EPSa Elektronik & Präzisionsbau, Saalfeld, Germany) is a hand-held electronic applanation tonometer developed from the work of Draeger et al over the last 40 years using a similar automation technology as the Home-Tonometer. The literature reports 67-90% of readings fall within 3mmHg of Goldmann's applanation tonometry (GAT).




**ICare rebound tonometer** (Icare Finland Oy, Helsinki, Finland) is a hand-held tonometer developed from the work of Kontiola et al in 1997. It electromagnetically measures the deceleration of a magnetic probe as it rebounds off the cornea. It has recently been modified to perform self-tonometry – the ICare One.

**Proview Eye Pressure Monitor** (Bausch & Lomb, Rochester, NY, USA) is a pressure phosphene tonometer invented by Fresco in 1997. It uses a spring compression gauge to record the IOP at which the entopic phenomenon is elicited. The sensitivity and specificity of the Proview and, indeed, the theory behind its operation is still contentious in the literature.


### Other tonometers that may be capable of self-tonometry are:

**Reichert AT555** and **Reichert Ocular Response Analyser** (Reichert Inc., Depew, NY, USA) and the **Nidek NT 4000** (Nidek Co. Ltd., Aichi, Japan) are all microprocessor-enabled non-contact tonometers that are capable of full automation. They are currently limited by cost, weight and connections to hardware and electrical sources. Nevertheless, a small group of glaucoma patients have reported success performing self-tonometry with the AT555 over the last few years.


Reichert AT555

**Tonopen** (Medtronic Solan, Jacksonville, FL, USA) is a hand-held electronic tonometer that is widely used in the clinic setting. A case report describes it being used successfully as a self-tonometer, but requires patient application of topical anaesthetic and co-ordination.

### References

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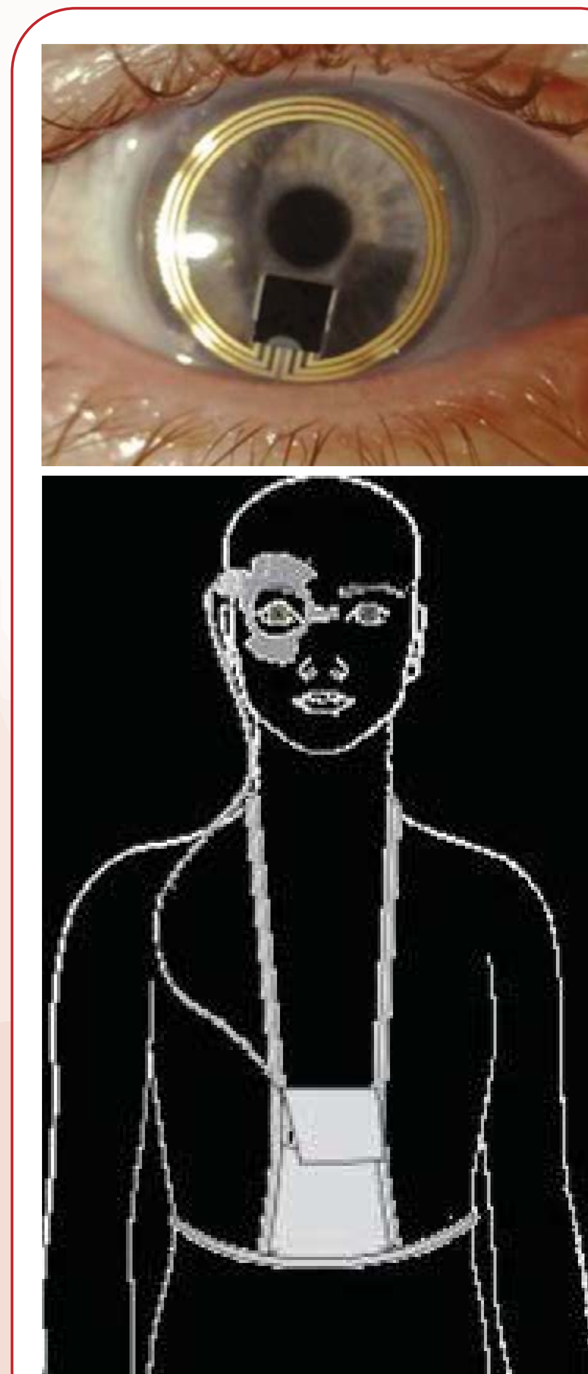
## The Future of Self-Tonometry?

### There are exciting new technologies undergoing human trials:

**Contact lens tonometer**, first proposed by Greene and Gilman (1974), is a contact lens mounted with strain gauges that measure the angular change at the corneoscleral junction due to change in IOP. In 2003, Leonardi et al introduced a modified tonometer, the **Sensing Contact Lens** or **Sensimed** (Sensimed AG, Lausanne, Switzerland), that measures the deformation of the central cornea curvature instead. Sensimed has obtained a CE mark for use in the Europe.


Sensimed

**Intraocular lens tonometer,** first proposed by Collins in 1967, was revisited 20 years later in a series of technical papers suggesting improvements using modern micromachining techniques of photolithography, fusion bonding and wet etching. Other authors suggested using a different material for the contact lens, transmitting data and energy by radiofrequency or transcutaneously, utilizing flexible microcoil technology for foldable sensors, calibrating with reference and temperature sensors, replacing the capacitor with a piezoresistive pressure sensor, and incorporating in-situ microprocessing for erroneous measurements. The main issues to overcome are related to size, signal transmission, long-term stability, optical functionality and risks associated with the invasive procedure.

**Spiral-tube iris-supported anterior-chamber tonometer** is an alternative intraocular sensor proposed by Chen et al in 2006. It is an iris-fixed Bourdon tube that records the IOP through direct mechanical deformation and read from the outside with a magnifier. Ongoing issues include size, weight, sensitivity to small IOP variations and complications related to manipulation in the anterior chamber.

## Conclusion

Research for the ideal self-tonometer should be directed towards both diagnosis and monitoring. It needs to be safe, reliable and easy to use. It should be either accurate over a wide range of IOPs or be able to be calibrated individually for accurate correlation with GAT. As a diagnostic device it needs to be minimally invasive, removable and require minimal patient and/or doctor training. As a long-term monitoring device it is ideally implantable, biocompatible, low maintenance and durable. It would address the diurnal change in IOP.

Self-tonometry will become integral to glaucoma management in the future. It will direct therapy, diagnose glaucoma suspects, allow self-medication, increase patient compliance, reduce routine visits, expedite review of acute angle closure attacks, potentiate remote center management via telemedicine, and further our understanding of glaucoma pathophysiology in ocular hypertension and normal tension glaucoma.