SENSIMED Triggerfish® provides an automated recording of continuous ocular dimensional changes over 24 hours.

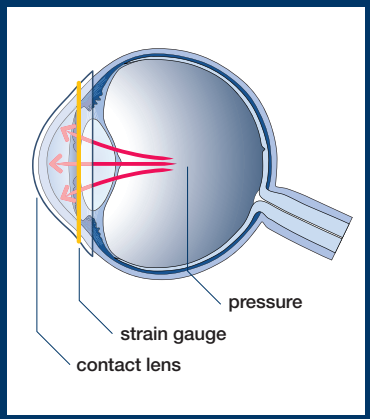

Fig 1. Circumferential dimensional changes in the area of the corneo/scleral junction, are captured by the highly sensitive strain gauge.

Technical white paper

Principles and rationale for the SENSIMED Triggerfish® Sensor device.

The Unmet Need

The desire to measure, monitor and control intraocular pressure (IOP) levels over a 24 hour period in patients suffering from glaucoma is, at present, expensive, problematic and inevitably leads to compromises. In essence, the effectiveness of the patient's therapy is determined retrospectively, however, the visual damage which indicates therapeutic failure is irreversible and sadly all too common. The current gold standard for measuring IOP, Goldmann Applanation Tonometry (GAT), is a technology more than 50 years of age. Its major drawback is the fact that it only provides a snapshot of IOP at a given moment and is normally used during office hours by ophthalmologists. GAT can provide multiple static snapshots of IOP during a 24-hour period but even this is cumbersome and relatively unphysiological since it requires the patient to be upright and awake. Current best practice for obtaining circadian profiles involves an overnight stay in a hospital or sleep laboratory, which induces substantial artifacts as well as the inconvenience of awakening the patient periodically only to obtain an approximation of the real IOP pattern.

The importance of the circadian nature of IOP fluctuation is gathering wide acceptance and a method non invasive of continuous monitoring under normal conditions of activities and posture, including normal sleep, could reveal important unseen information regarding the characteristics of ocular dimensional changes over 24 hours in each individual patient. The unmet need is the ability to effectively identify danger signs and assess effectiveness of treatment to prevent irreversible visual damage.

Principles of the SENSIMED Triggerfish®

The SENSIMED Triggerfish® Sensor device developed by Sensimed SA is a contact lens capable of recording qualitative profiles over a 24 hour period in patients with established glaucoma. The monitoring takes place while patients follow their routine activities. A strain gauge embedded in a soft silicone contact lens detects circumferential changes at the corneoscleral area *(Fig 1)*. This information is then transmitted to a recorder via a wireless telemetry system.

The relationship between these changes has been validated in vitro by Leonardi et al[1]. The following figures demonstrate the relationship between the output of the Sensor and manometrically measured IOP in an enucleated pig eye model both in simulation of ocular pulsation *(Fig 2)* and in slow stepwise ramping of IOP *(Fig 3)*.

The SENSIMED Triggerfish® in Use

In the clinical setting, the SENSIMED Triggerfish® provides qualitative information on the behavior of the individual patient's profile. Below is a typical 24 hour SENSIMED Triggerfish® profile as seen with the viewing software. The Sensor records for 30 seconds at 5 minute intervals during the 24 hour period. Each "burst" provides 300 data points. The software then filters out the high amplitude eye blinks in each burst and plots the median of these data points as a single point on the curve. Each point

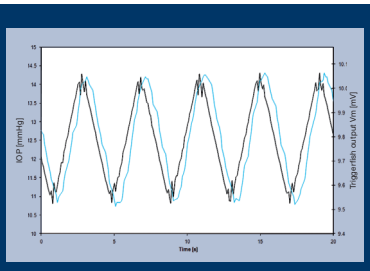

Fig 2. Recording of IOP variations and the Sensor's output signal (mV) during dynamic IOP variations in the enucleated pig eye simulating a typical ocular pulse amplitude of 3 mmHg centred at 12.5 mmHg. The Sensor follows IOP variation well. (Black line, IOP; blue line, mV).

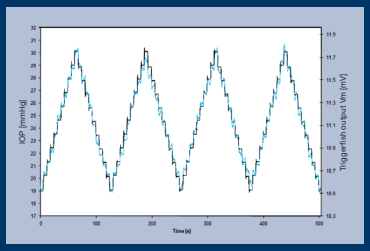

Fig 3. Recording of IOP and the Sensor's output signal (mV) during static IOP variations steps of 1 mmHg. It shows a high linearity and reproducibility. (Black line, IOP; blue line, mV).

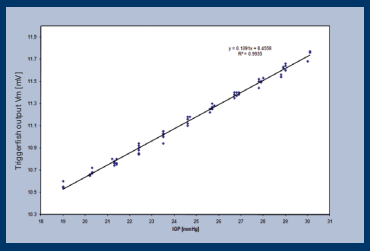

Fig 4. In static mode (median value of each 1 mmHg step shown in Fig. 3), the output signal of the Sensor (mV) has a highly linear behaviour (linear regression coefficient (R2) = 0.9935) and a reproducibility of ± 0.2 mmHg (95% confidence interval).

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on the curve represents a burst 5 minutes apart which taken together make up the 24 hour profile. The detailed view of any burst can be visualized in a zoom window beneath the main curve. It is notable that the system has a sufficient level of sensitivity to show the ocular pulsation, clearly visible in bursts recorded during sleep in the absence of blinking *(Fig. 5)*.

The curve appears to be unique for each patient and provides several pieces of important information.

1. The time of day or night when a peak is registered under physiological conditions. i.e. during normal activities, asleep with eyes closed and in supine/sleep body position.
2. How long the peak lasts and its rate of ascent/descent.
3. Treatment impact on the patient's profile by comparing two successive sessions.

Therefore, because glaucoma in each patient is different we can have individualized "signature" profiles to enable individualized patient treatment and monitoring of treatment effectiveness. Just how influential this data could be is still to be determined via clinical studies.

Conclusion

The SENSIMED Triggerfish® is a highly sensitive, non invasive system that records the ocular dimensional changes at the corneoscleral area over 24 hours. It has the potential to provide a way of personalizing treatment in glaucoma patients based on individual profiles. Its principles of measurement have been validated in both in vitro[1] and in vivo[2] studies and the device continues to be studied in clinical trials throughout the world.

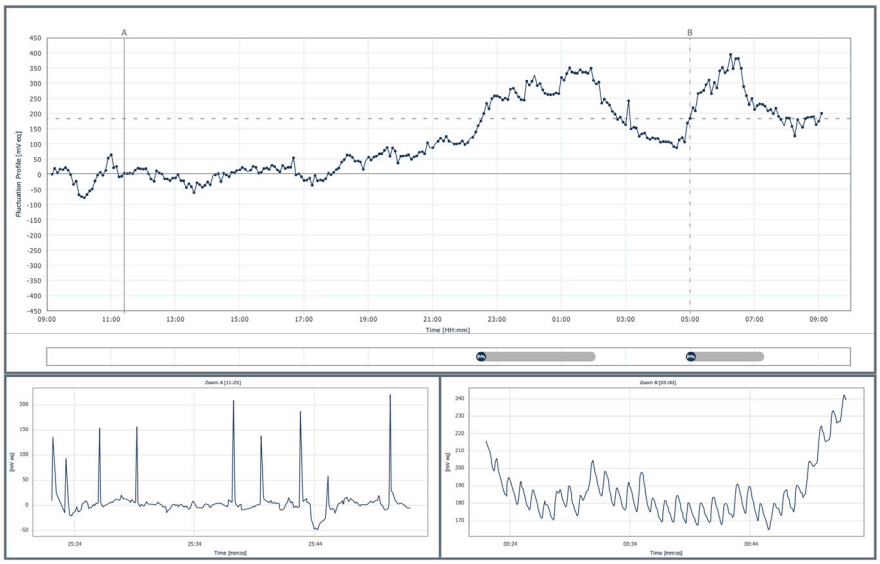

Fig 5. The SENSIMED Triggerfish® 24 hour profile as seen on the software which allows each point on the curve to be individually investigated by a zoom function. Eye blinks can be seen in details during 30 seconds in the zoom A window while ocular pulsation during sleep are shown in the zoom B.

REFERENCES

1. *Matteo Leonardi, Elie M. Pitchon, Arnaud Bertsch, Philippe Renaud and Andre Mermoud: Wireless contact lens sensor for intraocular pressure monitoring: assessment on enucleated pig eyes. Acta Ophthalmol. 2009: 87: 433–437.*
2. *Mansouri K, Shaarawy T. Continuous intraocular pressure monitoring with a wireless ocular telemetry sensor: initial clinical experience in patients with open angle glaucoma. Br J Ophthalmol 2011 Jan 7.*

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