Intraocular pressure estimates measured using a novel hand held tonometer

Pinakin G. Davey [1], John M. Maggiano [2], Laz C. Peterson [2], Steve Maurath [2], Peter Joson [3]

[1] College of Optometry, Western University of Health Sciences, Pomona, CA., [2] Orange County Retina, Santa Ana, CA, [3] Tayani Institute San Clemente, CA

Introduction

Intraocular pressure remains arguably the most important risk factor in glaucoma managemnet. The IOP estimates (IOPe) measured using various tonometers have some degree of relation with the "true" IOP (IOPt) and we continue to monitor and manage our patients with this parameter

The Goldmann applanation tonometer (GAT) is the current clinical gold standard due to its wide spread use. Numerous sources of errors influence the IOPe measurements obtained using the GAT of which notably are the corneal biomechanical parameters that have been discussed at great lengths in literature (Whitacre and Stein 1993). The variability of IOPe not only depends on physiological reasons like corneal thickness, corneal stiffness, corneal curvature, age of an individual, systemic disease etc. but also from measurement errors that stems from "performing tonometry" like improper positioning of probe, improper force etc. The GAT IOPe cannot be altered successfully to account most of these errors mentioned as it is a **subjective-analog** technology. However, IOPe obtained using newer devices that are **objective-digital** could use artificial intelligence machine learning classifiers to correct some or majority of sources of errors. In addition our project will democratize measurements of IOPe with the true GAT technology, including patients and non-ophthalmic professionals.

Purpose

LightTouch® tonometer (LT) is a novel prototype contact, hand held tonometer that estimates intraocular pressure (IOPe) in-vivo under topical anesthesia. Here we present the preliminary principles and calibration data of the LT and provide in-vivo IOP measurements obtained using the LT and Tonopen.

Materials and Methods

Three prototype laboratory probes were utilized in both the in-vitro and in-vivo experiments. The in-vitro experiments and testing was performed by an engineer and the in-vivo preliminary data collection by an ophthalmologist.

Working principles of LightTouch Tonometer

The principles of measuring IOPe using the LT device are based on simultaneous, objective, digital area and force measurements. Area measurement occurs via a decrease in total internal reflection within the device. This occurs when the device tip touches the corneal apex. Force is measured via a proprietary piezoelectric assembly. The distal end of the device contains an acrylic prism with a flat tip of 3.06 mm diameter. As the prism tip approaches the central cornea, the technician observes an aiming beam transiting the central cornea, and the patient assists in alignment by viewing the aiming beam target. After appropriate alignment the technician then briefly touches the corneal apex with a duration of 0.1 to 0.15 seconds, with a force of about 1 gram. During the touch duration the technician can see the measuring beam light (as it decouples from the device) illuminating the iris.

LightTouch Tonometer

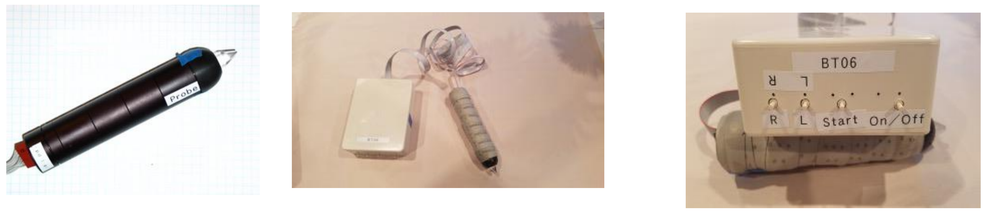


Figure 1. LightTouch Prototype probe and tonometer setup used in the experiments. This unit is the basis of the next generation of near commercial and commercial devices.

Figure 2. The envisioned final product of the handheld LightTouch tonometer. It will be a smaller probe, the optoelectronics will be included in the device and will fit both the right hand or left hand.

Figure 3. The envisioned LightTouch tabletop Tonometer suitable for clinics, with forehead rest and chinrest to monitor head position and stabilize the patient. A safety engineered robotic XYZ probe tip movement accommodates for the distance from patients eye. The last 2-3 mm to mimic a gentle practitioners touch.

Calibration experiments

Calibration experiments were performed utilizing a precise, programmable motorized sled with either 3.06 or 4.00 mm probe tip devices anchored to the sled. A rubber ball with duro and curvature similar to a human cornea was utilized. The calibration goal was to understand whether the probe construction yielded repeatable measurements at various force increments.

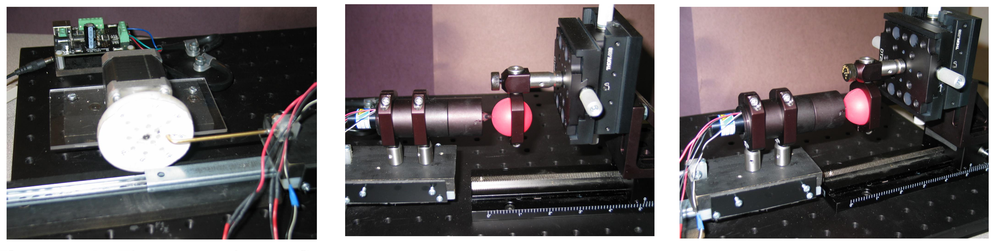
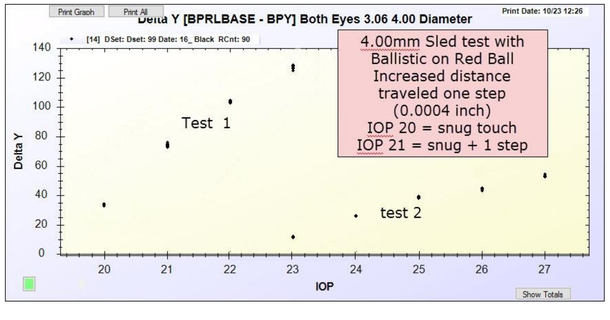


Figure 4 The top three figures show the programable motorized sled and the force measurements on the duro ball. Two probe sizes were utilized for this experiment 3.06 and 4.0 mm. The graph to the right shows that the measurement repeatability is very high. The steeper slope is data from the 4.00mm tip, whereas the shallow slope is data from the 3.06mm tip. Each "point" is an overlap of multiple point "smudge" due to high measurement repeatability.



LightTouch measurements in-vivo

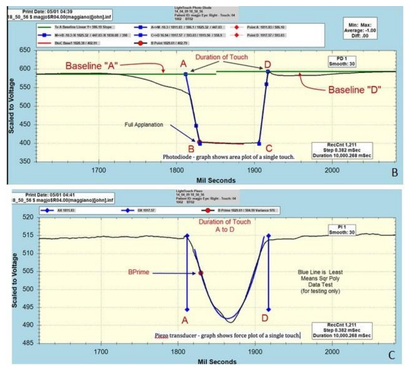


Figure 5. Top Panel shows an area waveform of one full touch to a human cornea. 'A' represents initial point of contact, 'B' represents the onset of full applanation. 'C' represents offset of full applanation. 'D' represents last point of contact between the probe tip and the cornea. **Bottom Panel** shows the force plot of the same touch. Maximum force is centered midway between time marks 'A' and 'D'. Touch tremor (raw data = black line) is seen at the touch midpoint.

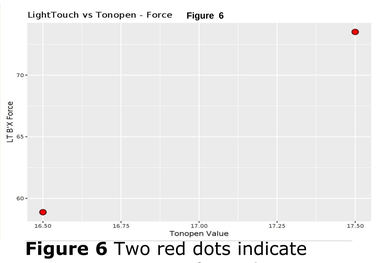


Figure 6 Two red dots indicate measurements performed on investigator eyes with LightTouch and Tonopen. In this data 1 mmHg corresponds to approximately 3.5-4.5 LightTouch units.

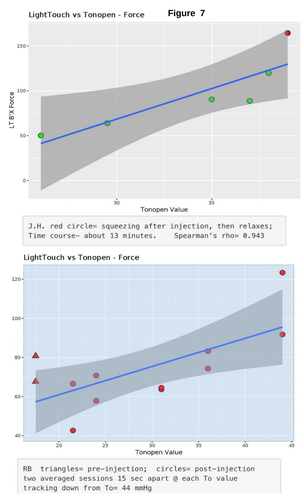


Figure 7 Shows two subjects receiving medically necessary intravitreal injection and measurements of IOPe obtained using the light touch 3.06 mm probe tip and Tonopen. compared

Conclusions

- The laboratory experiments indicate that the LightTouch device measurements are very repeatable at differing forces.
- The LightTouch device can provide IOPe data that is very sensitive to various fluctuations and correlates well with Tonopen values.
- Further in-vivo data and comparison results to other tonometers will establish the validity of LightTouch at all IOPe values.

Disclosures

Disclosures PGD None, JM is the inventor, holds patents and is the founder of LightTouch. LP is a consultant to LightTouch and was responsible for data modelling, SM is the systems engineer of this project, PJ is a consultant to LightTouch.

Any Questions and comments contact pdavey@westernu.edu 909-469-8473, lighttouch@Maggiano.net 714-264-0024