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IOP Measurement using Contact Tonometer by MEMS Technology

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Abstract-: ***One of the most critical bans of mankind is being blind. Yes, how sorrowing it is when you are not able to see this colorful world if you are blind. While we have heard of Cataracts and other macular degeneration, among them one such eye disease is Glaucoma that records affection over 3 million people in the United States. It is also known as "Silent thief" as it shows no symptoms but damages the optic nerve. It is caused mainly due to the pressure that is developed inside the eye known as Intra-Ocular Pressure. There are various tonometric methods at present to diagnose Glaucoma but the techniques are more dangerous to the eye. MEMS technology is one of the most upgrading and developing strategies that has created wonders in medical field. In this paper, we have proposed the concept of contact tonometer that makes use of a MEMS device which acts as a transducer/sensor thereby contacting with the cornea of the affected eye. The received electrical signal from the transducer is then processed and sent to the display indicating IOP. The basic concept and idea of MEMS enabled contact tonometer is found to be the most convenient mode of detection.***

Index terms: ***MEMS technology, IOP, Intra-Ocular Pressure, Glaucoma, Contact tonometers, tonometer, sensor, transducer.***

I. INTRODUCTION

Visual impairment is vision loss that causes difficulties in daily activities to a man. Some of the widespread causes of visual mutilation that are recorded worldwide are uncorrected refractive errors (43%), cataracts (33%), and glaucoma (2%). According to one of the surveys of The World Health Organization (WHO) estimation, 80% of visual impairment like cataracts, diabetic retinopathy, and glaucoma is either preventable or curable. Glaucoma is a sort of eye disease that is characterized by increased pressure that is developed within the eye known as intraocular pressure (IOP). If treated prior or diagnosis is done earlier, this type of optic nerve damage or glaucoma can be put an end.

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But till date, it isn't possible as there are no symptoms for Glaucoma and typical tonometric methods require touch with the cornea or direct eye contact that may result in infections in the eye if done periodically. Eventually, there are four main causes that serve to be the challenge for the diagnosis of Glaucoma:1) inflammatory ocular hypertension syndrome (IOHS); 2) severe uveitic angle closure; 3) corticosteroid-induced; and 4) a heterogonous mechanism related to structural transform and chronic irritation. At present, Glaucoma is more common in infants and also among kids owing to 10 years of age that is really shocking to hear. IOP has to be measured periodically to prevent glaucoma, many methods have been proposed for this cause but they are not effective when used frequently as they affect the eye. Hence this paper which is about the contact tonometer with the help of MEMS technology has been proposed to overcome the disadvantages.

II. MEMS TECHNOLOGY

Micro-Electro-Mechanical Systems, or MEMS, is one of the developing technologies that create miniaturized mechanical and electro-mechanical parts by the process of microfabrication. The essential physical dimensions of MEMS devices will vary from well below one micrometer on the lower finish of the dimensional spectrum, all the thanks to many millimeters. The varying categories of MEMS devices include easy structures with multiple complex mechanisms.

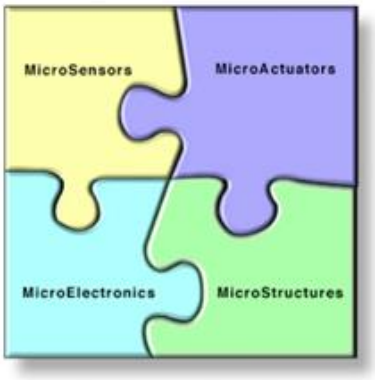

Fig.1. various categories of MEMS devices

At present with the help of MEMS technology, we have miniaturized each and every functional devices or structures like sensors and actuators. They are in turn termed as microsensors or microactuators shown in Fig.1. That has the ability to perform the same task of electrical or mechanical signal conversions.

It is the popular research area at present and many applications are built with the help of MEMS technology. Among them, the medical field is the one that has recorded more applications to date.

III. CURRENT TONOMETRIC METHODS

A. Goldmann Applanation tonometry

Goldmann Applanation tonometry is one such Applanation technique in which the IOP is measured by flattening the cornea up to 3.06mm diameter by applying a force. It was first introduced into the medical field in 1954 by Bern professor. In order to perform the measurement, anesthesia is used and for the purpose of highlighting the tear film area to take a measurement, a Fluorescein dye is located in the eye of the patient. The main disadvantage of this type of Applanation technique is that the depth depends on the central corneal thickness (CCT) factor and the value is low when the cornea thickness is thinner and high IOP is the result of the thicker corneal thickness. Additionally, corneal abrasion and usage of tropical anesthesia cause infections in the eye.

B. Tono-Pen tonometry

Tono-Pen tonometry method is categorized under Indentation tonometry strategies but also includes the aspects followed in cooperation of indentation and Applanation tonometers. As its name suggests, it is a handheld miniature battery-based tool that makes touch with the eye. When a force is applied, plunger gadget measures the resistance factor generated by the cornea and all the readings are taken into account. An average is calculated from them and the resultant value is the IOP value that equals fine with values got from Goldmann technique.

C. Ocular blood flow tonometry

If IOP measurement is to be taken from post-keratoplasty eyes, ocular blood flow tonometry proves to be a suitable one compared to the above-discussed methods. If the corneal pathology is found to differ, then this sort of pneumotonometer method is reliable. The mode of taking the measurement is quite different where for every single subject, we make use of separate tag OBF and the membrane of the patient is exposed to the slit lamp for about 6-10 seconds and values are taken. Infraction of seconds, more than 100 readings are taken and unlike Tono-pen tonometer, the values are averaged to find the resultant IOP value.

D. Non-contact tonometry

Air-puff tonometer or Non-contact tonometer is the easiest technique to perform the IOP measurement where a small air puff device blows air and thereby measuring the pressure within the eyes without any direct contact. You never need to maintain a corneal or direct contact with the cornea and need of topical anesthesia isn't necessary for this mode of measurement. Local anesthesia can be used and thereby corneal abrasion and drug infection problems are put an end y this "puff test" or non-contact tonometers. The basic non-contact tonometer introduced in the year 2005 is given in Fig.2.

Fig.2. Non-contact tonometer

E. Statistical analyses

Statistical Analysis is performed on various above discussed tonometric methods and a Bland-Altman plot is plotted that is shown in Fig.3. It is carried out in the Microsoft Excel platform. We have plotted method differences in an axis and the inter-method comparisons in another axis.

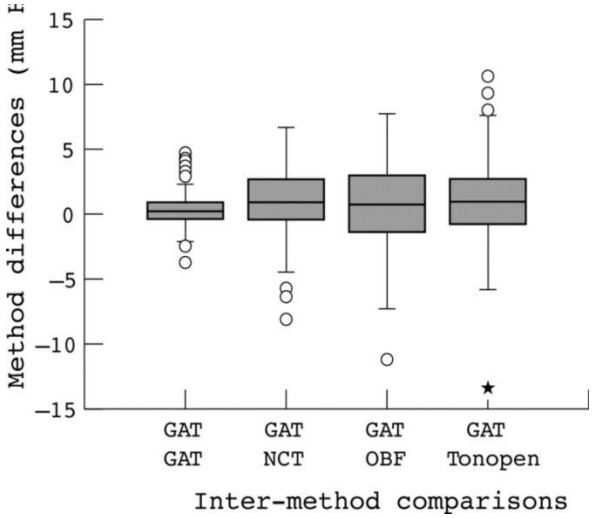

Fig.3. Comparison of various tonometric methods

All of these methods cannot be used frequently as it affects our eyes. Hence contact tonometric method with MEMS technology is used in the case of measuring IOP which overcomes all these methods.

IV. CONCEPT AND IDEA OF CONTACT TONOMETER USING MEMS TECHNOLOGY

The basic design of contact tonometer designed with the aid of MEMS technology is shown in the Fig.4. As it can be seen it consists of a contact end in the front that makes the contact with the contact surface of the intended eye usually cornea.

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The MEMS device then sends an electrical signal once the contact is made with the surface and force is applied. Usually, the MEMS device acts as a transducer/sensor. The received electrical signal is then caught by the electronics unit next to the device. The electronics unit consists of a microprocessor and it can be said that the MEMS device and electronics unit is an integrated circuit. It converts the electrical signal to the IOP signal representing the pressure of the contact eye. It is then displayed on the display unit. Additionally, we can see the activation switch and connection member that takes part in the alignment tool.

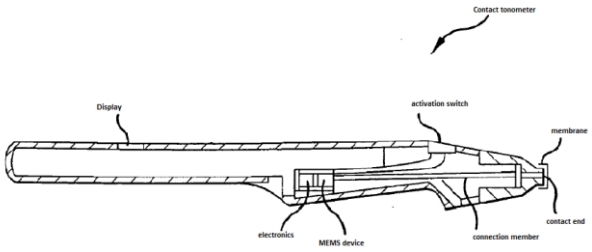

Fig.4. Contact tonometer

Schematic diagram of the present invention is shown in Fig.5. It is a block type representation of the contact tonometer. There is a power device attached to the invention in order to provide power supply to the electronics unit and it is basically batteries.

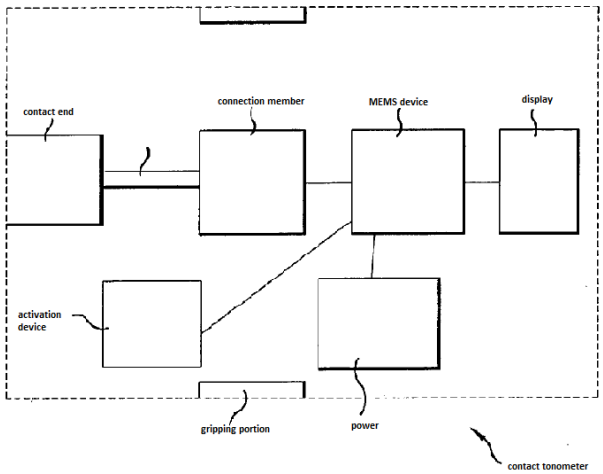

Fig.5. Schematic of the present invention

When the above schematic is implemented in the form of the device then the outlook of the invention would be represented in the form of Fig.6. The housing constitutes the electronics unit and MEMS device.

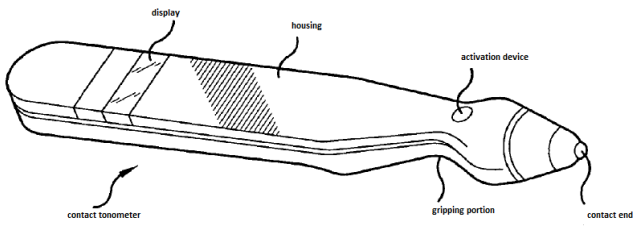

Fig.6. Side view of the contact tonometer

One of the most interesting facts about this invention is that it can be represented in the form of the hand-held device too shown in Fig.7. It can be easily connected to the hand while the first housing member is connected to the finger comprising of a contact end and MEMS device. The second housing member is coupled to the first member and connected to the human hand that comprises of the activation switch, display and the power supply of invention.

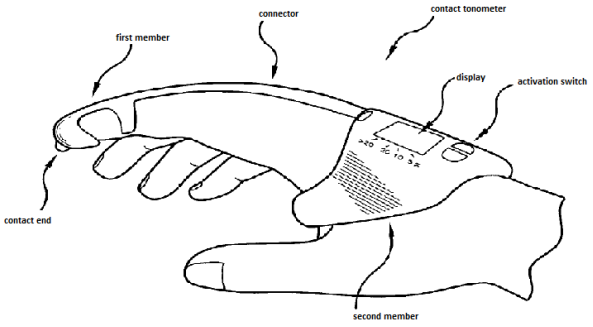

Fig.7. Hand-held contact tonometer

V. EXPERIMENTAL RESULTS

In order to evaluate the performance of IOP measurement using MEMS devised contact tonometer, we have performed a simulation with the aid of COMSOL tool. The test is carried out on a capacitive circular plate with perforations that are movable. The sensitivity is found to be high indicating high presentation.

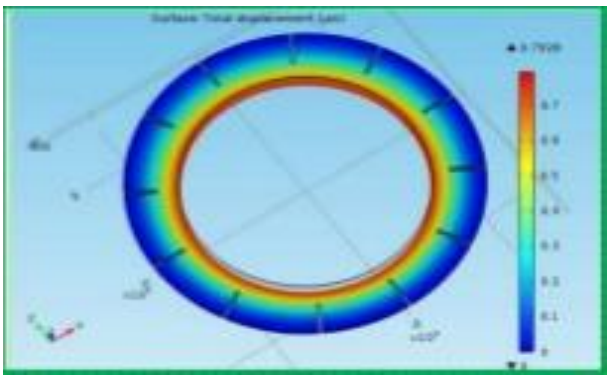

Fig.8. Simulation result

VI. CONCLUSION

A general idea of contact tonometer along with schematic and experimental results is summarized in this paper. Thereby with little effort and efficient MEMS technology, IOP of an eye is measured effectively without any complications in the eye. While the previous tonometric methods aren't applicable for frequent measurements, this concept of contact tonometer is really reliable and highly convenient without any hassle. Hence, Glaucoma can be found at an earlier stage and can be treated with no complications and thus blindness is kept a full stop.

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