The Appliance for Mastering the Technique of Measuring Intraocular Pressure

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Abstract: In this article, we present the results of developing the hardware-and-software appliance for mastering the skills of measuring intraocular pressure in humans. The appliance was designed to match authentic clinical conditions used to acquire practical skills in measuring intraocular pressure. The hardware-and-software appliance was tested at the stand using various types of tonometers, and the results were quite promising.

Keywords: appliance, hardware, software, intraocular pressure, clinical practice application.

Introduction

The study of intraocular pressure (tonometry) is widely used in medical practice. Tonometry is a mandatory practical skill of an ophthalmologist. By the order of the Russian Federation Ministry of Healthcare, preventive physical examinations of the population include mandatory tonometry, which ensures the detection of early signs of ophthalmic hypertension and glaucoma.

In this regard, the study of intraocular pressure is conventional examination method for all population categories, including those with already established diagnosis of glaucoma. In clinical practice, various types of tonometers are used, differing both in design and investigation technique. Consequently, there are also differences in measurement results. Hence, it is necessary to test tonometers in order to compare measurement results.

In current medical practice, intraocular pressure measurements through the eyelid are used. These are the most up-to-date and effective research methods. They are employed in the course of mass physical examinations at polyclinics, as well as to monitor a patient condition in a clinical setting. We developed the computer appliance to test the precision of human intraocular pressure measurements via various methods and used it at medical institutions to improve the tonometry efficiency. Comparison of the measurement results would improve the examination accuracy and prevent the misuse of the tonometry technique by various types of tonometers.

Our study aimed at developing the appliance for mastering the technique of measuring intraocular pressure in people.

Materials and Methods

We developed the hardware and software components of the original appliance for mastering the technique of measuring human intraocular pressure.

The design of pressure control sensors in the hydraulic system is adapted to providing a standardized pressure. It includes two sensors, and a precision resistive strain gauge detecting the pressure in the hydraulic system at the moment the pressure was applied to the piston. The second strain gauge and the sensor module are located in the working measuring area of the hardware. The combination of two gauges ensures the ability to provide feedback between the hydraulic system and the stepper motors. Pressure regulation in the hydraulic system is provided by the piston movement.

To fix the stepper motors and the strain gauge, the design was developed that ensured the movement of mechanical elements and their coaxiality. The fixing structure was made of plastic on a 3D printer. The materials were selected that provided necessary ergonomic requirements and the ability to operate in the specified parameters.

The software monitors the readings of both strain gauges. After the pressure data is confirmed by two strain gauges, it is possible to test the tonometers. The control is carried out by a computer program. During testing, the tonometer touches the upper eyelid area, similar to the conventional examination procedure.

The software for controlling the piston and, accordingly, the level of pressure in the hydraulic system, regulates the parameters of the interaction between strain gauges and stepper motors. The elements are controlled by a microcomputer. The entire system and control units are located inside the simulator of a human face. The hardware performance check was carried out at each stage of the design and assembly of the entire appliance. We undertook testing mechanical elements, and operating the sensors, hydraulic elements and power supply, along with their interaction with the control unit.

To control the parameters of changing the pressure level in the hydraulic system of the hardware part of the appliance, the original software was developed. The program is designed to control the hardware unit for regulating the pressure level in the hydraulic system in order to test ocular tonometers. It is used to provide a change in the pressure level in the hydrodynamic system of the hardware-and-software complex for testing ocular pressure meters.

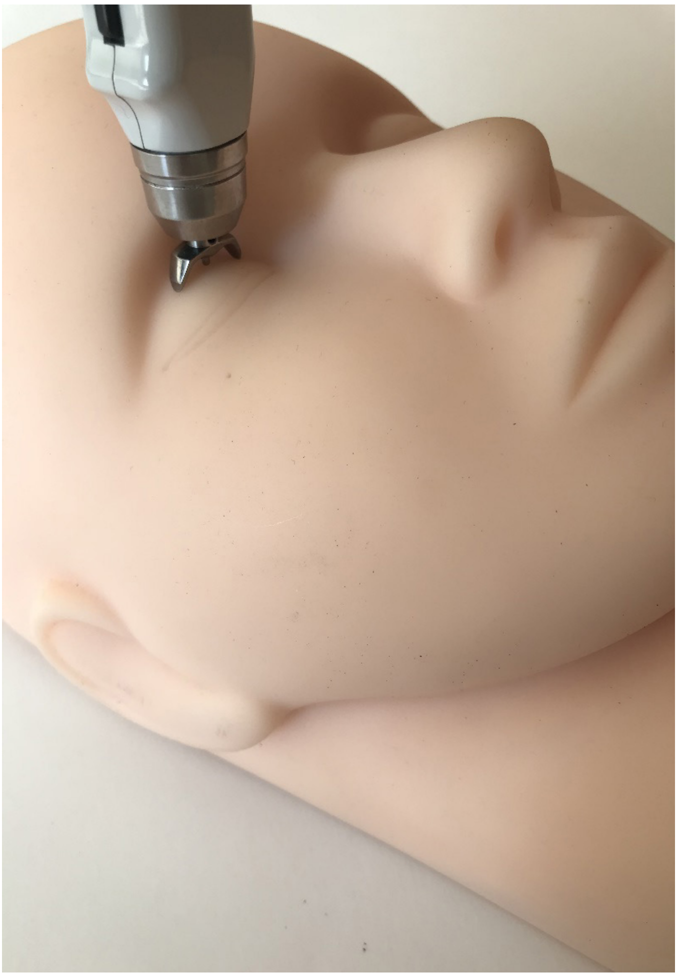

Figure 1. Testing the intraocular pressure measuring appliance

The software provides the following functions: increasing and decreasing the pressure in the hydraulic system of the appliance hardware in the range from 5 to 60 mm Hg with a pressure step of 2 mm Hg via controlling stepper motors, moving the piston system and controlling the pressure according to the readings of the strain gauges.

Results and Discussion

We tested the hardware-and-software appliance at the stand using various types of tonometers. The pressure in the eye simulator was controlled manually. The technique was standard, as indicated in the guidelines, via touching an upper eyelid with a tonometer plunger.

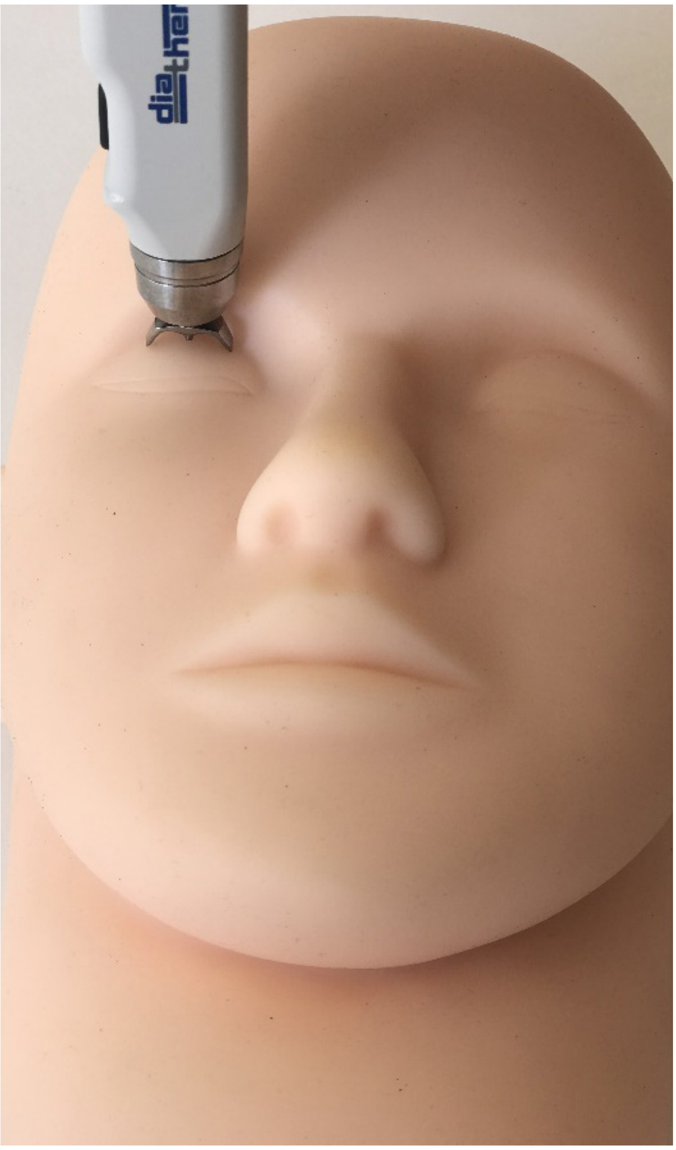

Figure 2. **Measuring intraocular pressure with a DIATHERA tonometer**

The measurements obtained by the IGD-02 intraocular pressure indicator matched the data on the generated pressure in the hydraulic system and the eye simulator, specifically, the pressure ranges corresponding to the clinical ranges: hypotension – below 18 mm Hg, normotension – 18-26 mm Hg, and hypertension – 26-34 mm Hg. All modes were set using the created software.

The hardware-and-software complex was tested in the conditions approaching clinical, i.e., on a face simulator of an adult human. The sizes and localization of the palpebral region were fully consistent with geometric dimensions and with the methodology for investigating intraocular pressure.

Also, in the course of our research, in addition to the intraocular pressure indicator IGD-02, DIATHERA tonometer was used. The test results matched the pressure in the system of the appliance.

Conclusion

We developed the software for the hardware of the intraocular pressure measuring appliance, as well as for the unit controlling the parameters of the strain gauges and the feedback program. We have also developed the software for analyzing the data collected during the research. The hardware-and-software appliance was tested at the stand using various types of tonometers. The conducted patent search confirmed the originality and lack of analogues of this development. The patent certificate for the developed software was received. Currently, the hardware-and-software appliance for mastering the technique of measuring intraocular pressure in people is undergoing clinical testing.

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