

Eyelid pressure

N.J. van de Berg¹, E.A. Arkenbout¹, R.J. Visser¹, S. Schutte¹, F.C.T. van der Helm¹, W.A. van den Bosch², H.J. Simonsz³. ¹BioMechanical Engineering, Delft University of Technology, Delft, The Netherlands; ²Eye hospital Rotterdam, Rotterdam, The Netherlands; ³Ophthalmology, Erasmus Medical Center, Rotterdam, The Netherlands

Summary

In surgical correction of eyelid disorders the technique chosen may depend on lid laxity. This property can be formulated as the pressure the eyelid exerts on the eyeball. An attempt has been made to define standards for this lid pressure. The hypothesis under consideration is: *The eyelid pressure from people in the age category 40-60 is lower than people from the age category 18-25.* So far no significant differences in eyelid pressure have been found. Further research in a third 65+ age category and the addition of other independent variables will have to be performed.

1. Introduction

There are numerous types of surgeries which involve the eyelid (for example removing excess skin from the eyelid, or the removal of a tumour). In these surgeries the eyelid often needs to be altered and afterwards be given time to fully heal. There is no guarantee beforehand that a surgery has fully succeeded and the eyelid itself has got the right amount of prestress. This can only be judged by the surgeon with his/her previous experience and the patient during and after the healing process. If it would be possible to determine the eyelid pressure before the surgery and compare it with data collected from healthy people from the same age category, it is then possible to determine whether the eyelid pressure of the patient is correct or needs to be adjusted.

Another field in which the knowledge of the eyelid pressure gives an advantage is during the stage of diagnosis. When a patient is suffering from a disease like Graves' disease (a thyroid disorder), a higher eyelid pressure can be expected due to a translation of the eyes up to 8 mm perpendicular to the orbit. There are also disorders which can lower eyelid pressure. Early measurements of the lid pressure and comparison to healthy data can give considerable insight into the state of the disease.

In order to define this lid pressure standard a wide range of possible independent variables should be taken under consideration. This initial research is mainly focussed on the influence of age. The following hypothesis has been used: *The eyelid pressure from people in the age category 40-60 is lower than people from the age category 18-25.* Other aspects like fatigue, stress factors and genetic influences have been neglected in this research. Distinctions have only been based on age and gender. Ethnicity was kept constant.

2. Method

The research is threefold. Two fully separate tests have been designed in order to determine two separate variables, the pressure between eyelid and eye (P_{eye}) and the prestress force (F_{lid}) of the eyelid. These variables have been linked through a theoretical model of the eyelid.

In order to determine the pressure between the eyelid and eyeball a small device has been designed which is to be placed by a surgeon under the eyelid for the duration of a few seconds to measure the eyelid's pressure. This sensor with its casing can be seen in figure 1.

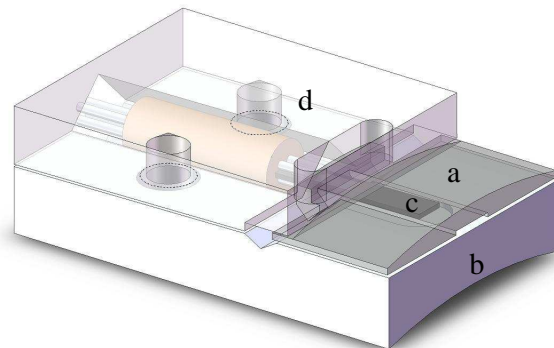


Figure 1: Sensor and casing (dim: 13x8x4 mm)

The dark surface (a) is the actual surface on which the eyelid rests. The bottom (b) rests on the sclera of the eye. While placed under the eyelid, the eyelid pressure presses the surface down which in turn is countered and measured by the sensor (c) lying within the casing. The sensor is based on strain gauges placed on a small beam which measures the deflection of this beam.

The whole casing (d) can be taken apart in order to meet sterilisation demands. The sensor is also easily replaceable.

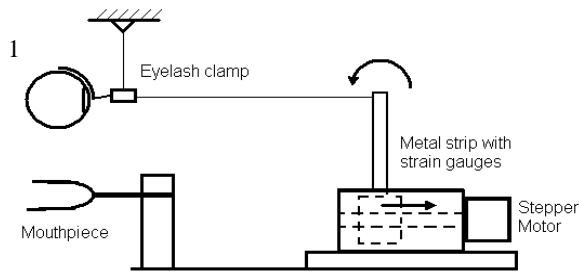


Figure 2: Test for determination prestress eyelid

The second variable is the prestress strength of the eyelid. This has been measured by determining the force required to stretch the eyelid for a distance of approximately 5mm. The translation which is put upon the eyelid is fully controlled. The global setup of the test can be seen in figure 2.

A stepper motor is used to induce a constant translation of a small metal strip on which two strain gauges have been placed. These two strain gauges form a half bridge of Wheatstone. With the translation the eyelid stretches out anteriorly and the small metal strip bends as a reaction to the force. This bending is measured for both stretching and contracting of the eyelid and calculated to the force required.

In order to interpret the measured values of P_{eye} and F_{lid} and to increase the understanding of the lids properties a mechanical relation has been created in MATLAB. This theoretical model is based on the area of the eyeball which is covered by the tarsus. This area is calculated using the geometry of the eyelid and its attachment points relative to the geometry of the eyeball. The model then leaves us with two variables; the eyelid pressure P_{eye} and the eyelid prestress force F_{lid} of which the measurement processes have been discussed previously.

3. Results

The test in which the eyelid pressure is to be measured with the small designed sensor for placement directly under the eyelid has not been completed yet. A prototype of the casing is currently being manufactured and testing will begin in January.

The second test for determining the prestress force of the eyelid has produced promising results. In general all results show a likewise shaped graph. Another

observation made is that in stretching the eyelid anteriorly a different line is produced than during the contraction. In this situation an exponentially decreasing relation is visible. Figure 3 shows the force required for stretching and contracting the eyelid versus the translation of the eyelid of two people who represent their respective age category.

The created theoretical model is shown in figure 4.

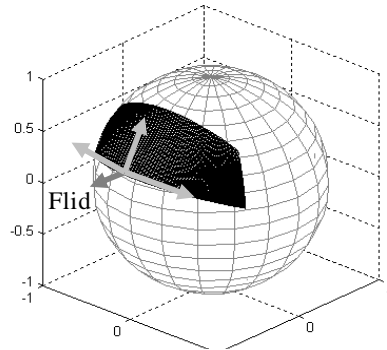


Figure 4: Theoretical Model

4. Discussion and conclusion

The test groups (18 test subjects in the category 18-26 and 11 test subjects in the category 40-60) are large enough to give a general indication of the path of the graph and the resulting differences between the considered age categories. The hypothesis is likely to be true, however the difference between the age categories is small and more measurements should be performed in order to reach a significant distinction which can lead to more definite conclusions. Other points of interest would be to test a third age category (65+) and taking other independent variables like fatigue, stress factors and genetic deviations into consideration.

In order for surgeons to be able to work with a lid pressure standard a continuation of this research is mandatory. If the sensor, which is currently under construction, turns out to be accurate another important step forward in this research has been made.

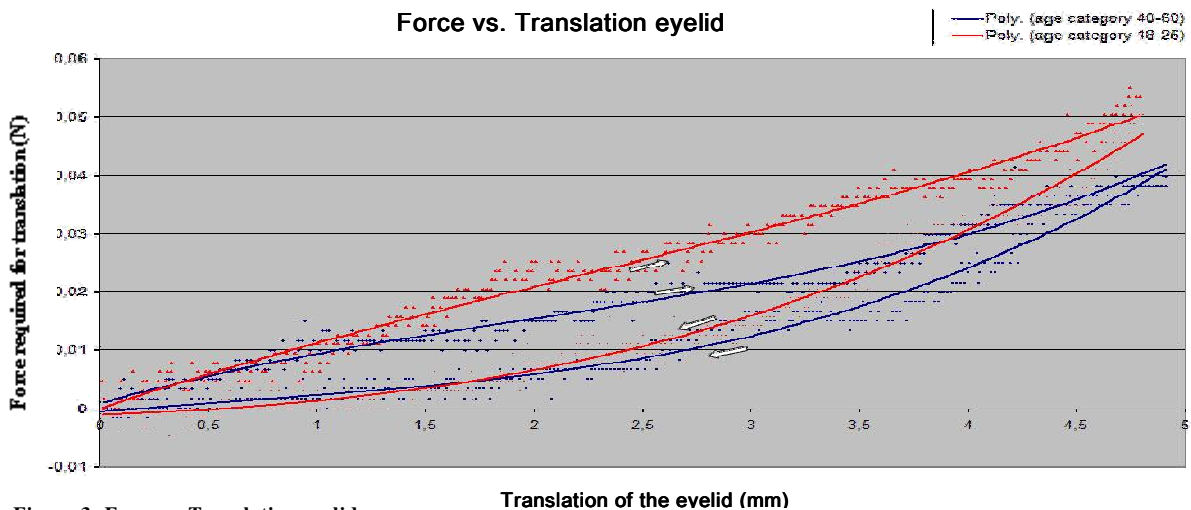


Figure 3: Force vs Translation eyelid