Objective Measurement of Eye Movement during Surgery using the Electro-oculogram

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A portable eye monitoring system for use during Endoscopic Sinus Surgery to warn the surgeon in the event of movement of the eye caused by surgical tools, has been designed and developed.

During endoscopic sinus surgery, there is a high risk that the surgical instruments used could cause damage to the patient’s eye. If this damage is severe, blindness or loss of the eye can result. A surgical instrument inadvertently penetrating the lamina papyrus (a very thin bone which separates the eye from the nasal cavity) will cause damage to the eye. However, before damage can occur, the instrument will come in contact with the medial rectus or superior oblique eye muscles, causing the eye to move from right to left or diagonally. Movement of the eyeball is the primary indicator and early warning sign of damage or impending damage to the eye by the surgical tools, to the eye and surrounding tissue. Current best practice monitors the eye movement by taping up the eyelids and having a healthcare professional watch for movement in each eyeball.

The developed system uses the electro-oculogram [EOG], a faint electrostatic field that rotates with the eye and is generated by corneal-retinal potential as well as muscles that orient and focus the eye. It is most often used in ophthalmology in diagnosing ocular disorders and in psychiatric research. The EOG is measured by means of electrodes placed on the skin around the eye and is generally defined in the range 0.1-34Hz.

The system provides continuous monitoring of the movement and behavior of the eyeball during sinus related surgery and generates audible and visual feedback on eye movement caused by surgical manoeuvres. This system is intended to remove the subjectivity and margin of error which characterizes current best practice. This objective eye monitoring instrument improves the safety of the procedure and provides a facility to detect ocular micro-tremor.

A novel biopotential amplifier which prevents amplifier saturation while retaining feature integrity was developed and is used for analogue processing. Digital processing including automatic sensitivity calibration to each subjects’ baseline EOG is performed in real time on an FPGA. The ‘bottleneck’ sampling rate is 191Hz which means the unit produces a response every 1/191 (0.00523) seconds. The instrument is currently under test at the Department of Otolaryngology at Beaumont Hospital, Dublin.

Key words: Endoscopic sinus surgery, biopotential, Signal Processing, Electrooculogram