

2016 – 2017 ONTARIO GRADUATE SCHOLARSHIP – *Plan of Study*

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Proposed Project: Development of Surgical Instruments for Endoscopic Ear Surgery

Minimally invasive surgery reduces trauma to the body, scarring, recovery time and length of hospital stay [1]. Middle ear surgery is traditionally performed through an external incision with visualisation of delicate anatomical structures using a microscope. More recently, surgical techniques have been developed using endoscopes to access the middle ear through the ear canal without an external incision [2,3]. As with open microscope-guided surgery, this transcanal endoscopic ear surgery (TEES) technique, allows the surgeon to perform procedures such as ear drum reconstruction, skin growth removal and hearing bone repair [2]. The principle challenge with TEES is that a one-handed surgical technique is required as the endoscope is held in the other hand. Otologic instruments were developed for two-handed microscope-guided surgery so they are not all well suited to TEES conditions [3]. These shortcomings have hindered the use of TEES and will be addressed by this project which will utilize mechanical engineering principles to develop specialized instruments for TEES [4,3]. While previous instruments were developed by surgeons over decades through trial and error, modern engineering techniques provide the opportunity to rapidly design and produce ergonomic functional instruments optimised to facilitate this new branch of surgery.

The proposed Master's project will start in September, 2016 at the University of Toronto Institute for Biomaterials and Biomedical Engineering (IBBME). The objective of the project is to develop and evaluate surgical instruments that facilitate one-handed surgery for TEES. First, a survey will be conducted to compile the needs of endoscopic ear surgery from various ENT surgeons to develop design criteria. Designing and developing surgical instruments by collaborating engineering design principles with input from endoscopic ear surgeons will aim to address these identified criteria and increase control during TEES, replicating two-handed manoeuvres. Tools will be designed to improve grip and manoeuvrability of synthetic grafts and enable accessibility in hard to reach places within the middle ear. A functional prototype has already been developed by the student and supervisor to facilitate graft manipulation and has been tested inside a cadaveric ear canal which will be further developed to increase functionality and manufacturability.

Development of the tools will follow an iterative engineering design process. Preliminary virtual designs will be developed, with the aid of virtual models of the ear canal using CT scan reconstruction technology. Initial prototypes will be manufactured using 3D printing and machining techniques and tested in 3D printed and cadaveric ear canals by various endoscopic ear surgeons. Test results will drive further iterations of the design and functional prototypes will be designed for machinability and sterilizability to produce final prototypes. Engineering drawings will then be drafted for professional machining of the instruments, to be used in the operating room. This project will demonstrate the feasibility of using CAD modelling and printing technologies to expedite design of novel surgical instruments for new procedures. The resources required to design, prototype and test instruments are available at the IBBME, SickKids Hospital and Mount Sinai Hospital, all of which were used to design the initial functional prototype.

It is anticipated that new TEES instruments will increase the range of ear procedures that can be completed minimally invasively and increase the speed and effectiveness of surgery. The instruments could also be used for other minimally invasive surgery in bony cavities such as sinus, nasal, spinal and arthroscopic surgery [6,7]. It could be envisaged that ultimately, virtual patient models could be used with rapid prototyping and fabrication to create patient specific specialist instruments to extend the limits of minimally invasive surgery even further.

Bibliography:

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