The aim of this project is to develop and evaluate innovative surgical instruments for the new and growing field of endoscopic ear surgery, a minimally invasive technique. By employing an endoscope during surgery, the middle ear can be accessed through the ear canal without an external incision [1] [2]. As with traditional, invasive 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 [1]. The Hospital for Sick Children remains one of the very few centres in North America where a surgeon completes the majority of middle ear procedures endoscopically. The learning curve to reach this status has been slow, taking many years, but the wealth of experience accumulated has given valuable insight into the strengths and weaknesses of currently available instrumentation for endoscopic ear surgery.

The principle challenge with TEES is that a one- handed surgical technique is required while the endoscope is held in the other hand, this makes the surgery more difficult, and requires enhanced training. Otologic instruments were developed for two-handed microscope-guided surgery so they are not all well suited to TEES conditions [2]. 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 [2] [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.

*Aim 1:*A needs assessment survey, using the Delphi method, will be conducted to determine the requirements to address in order to encourage more surgeons to train in and employ TEES. A list of questions will be formulated based on local otolaryngologists’ feedback, and a survey will be sent to otolaryngologists globally. The results will then be published to establish the requirements to enable training and development of endoscopic ear surgery. A time flow analysis recording the duration of surgical steps will also be conducted to quantify the limitations of current instruments used in endoscopic ear surgery, by assessing their efficiency.

*Aim 2:*An initial, functional prototype, developed by the supervisor and student, was designed to facilitate manipulation of a synthetic graft during ear drum reconstruction surgery. New instruments in response to the needs assessment will also be developed, for example to ease control of bleeding and to access hard to reach places in the middle ear, with one hand operating. The instruments will be designed to optimize functionality, ease of use and maneuverability of the tool within the ear canal alongside an endoscope.

*Aim 3:* Validation testing will be conducted and published to compare existing tools as well as the new instrument designed. A mock operating room setting will be used where surgeons will test the tool on cadaveric or 3D printed ear models by performing an ear drum replacement procedure and trying to reach hidden recesses behind the ear drum. The number of tries to pick up and place the graft and time to complete the procedure will be measured to assess the efficiency, functionality and ease of use of the tool. As well, qualitative feedback, in terms of ease of use and ergonomics, will be obtained.

*Aim 4:*Collaborate the obtained feedback to optimize the tool so it can be used in patients in the operating room.

**Significance:**

The design techniques and instruments created will also be applicable to other minimally invasive surgery in bony cavities such as sinus, nasal, spinal and arthroscopic surgery [4] – [6]. It could be envisaged that ultimately, virtual patient models could be used with rapid prototyping and fabrication methods, developed by this project, to create patient specific specialist instruments to extend minimally invasive surgery.

**Expected Outcomes:**

As per informal discussions with otologists at SickKids, the needs analysis survey will show that surgeons find one handed surgery and bleeding control the major challenges in endoscopic ear surgery. They have conveyed that future tools whose primary functions are coupled with suction would be beneficial to aid surgeons while performing this new type of surgery. As well, it is expected that the new tool will encourage more use of endoscopic ear surgery by easing the procedure and increasing efficiency.

**Impacts on Endoscopic Ear Surgery and Patients:**

The development of tools to facilitate endoscopic ear surgery aims to encourage more ear surgeons to adopt this minimally invasive surgical technique and therefore reduce patient morbidity rates and send patients home sooner so they can go back to their normal lives. Endoscopic ear surgery has been shown to reduce rates of residual skin growth after skin growth removal surgery in the middle ear as the endoscope allows greater visualization in the previously hidden recesses within the middle ear [7].

3.

References\*

List the references in your research proposal here. **Maximum 4,500 characters (with spaces), which is equivalent to about 1 page single spaced in Microsoft Word, 10 point Arial font.**

[1] A. James, "Endoscopic Middle Ear Surgery in Children", Otolaryngologic Clinics of North America, vol. 46, no. 2, pp. 233-244, 2013.

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[4] “Benefits of Minimally Invasive Surgery | AIMIS.” [Online]. Available: http://www.aimis.org/benefits-of-minimally-invasive-surgery/. [Accessed: 14-Nov-2015].

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[7] Ã. A. L. James, Ã. S. Cushing, and Ã. B. C. Papsin, “Residual Cholesteatoma After Endoscope-guided Surgery in Children,” pp. 196–201, 2015.