Background: The endoscope has allowed minimally invasive surgery to be possible through the ear canal, a natural opening of the body, for middle ear surgery, without the need for an external incision [1] [2] [13]. As with traditional, invasive microscope-guided ear surgery, transcanal endoscopic ear surgery (TEES) allows the surgeon to perform common procedures such as ear drum reconstruction, skin growth removal and hearing bone repair, through the ear canal [1]. TEES is a one-handed surgical technique and this has discouraged many ear surgeons (otologists) from adopting it as current instrumentation, designed for two-handed use, does not facilitate operating single-handedly alongside an endoscope [3]. However, the endoscope allows for: better visualization of the structures within the middle ear, more effective surgical skin growth removal, preserving the hearing bones, and relief for patients and families as a skin incision is not required [13]. A survey reported that out of 80 Canadian otologists, the adoption rate of TEES is less than 10% but 50% are likely to use it in the future [3]. Although, the literature has not yet reported specific reasons as to why TEES adoption is low, and so there is little knowledge as to how to improve its use.

Objectives and Hypothesis: In order to increase the use of TEES, the following will be investigated: a) the reason for surgeons not adopting TEES by conducting a questionnaire for otologists and b) limitations of existing tools by conducting a surgical time flow analysis. This will develop criteria against which new instrumentation will be designed and tested using 3D models of the ear. TEES is recognized for its potential and the investigators hypothesize that by conducting a needs analysis survey and a surgical time flow analysis, current limitations of TEES will be developed and new instruments will be fabricated and tested, using mechanical engineering design principles, to address these needs to improve the adoption of TEES. This project aligns with CIHR’s mandate as TEES is a surgical technique being used internationally and the objective of the project is to encourage greater use of the technique and TEES allows safer, more effective surgery in the middle ear (<http://www.sinuscentro.com.br/iwgees/group.htm)> [2].

Experimental Approach and Methods/Procedures: *Aim 1:*A needs assessment survey, using the Delphi method, will determine the requirements to increase surgeon adoption of TEES. Questions have been developed based on local otolaryngologists’ feedback, and a survey will be sent to otolaryngologists globally. A time flow analysis, recording the duration of surgical steps, will quantify the limitations of current instruments used in endoscopic ear surgery, by assessing their efficiency. This data will be analyzed statistically and published in a peer-reviewed otolaryngology journal, to address this knowledge gap. This analysis will ensure that the tools are designed for the surgeon to use effectively, safely and efficiently.

*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.

These aims will be accomplished by integrating the pillars of CIHR: biomedical engineering, by developing tools, clinical research, by testing the tools in CT-scan generated 3D printed ear models and this will all aim to increase the adoption of TEES which will positively affect the healthcare system, due to the minimally invasive surgery benefits to the hospital and patient because of shorter hospital stay and less patient morbidity [4].

**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.

These tools will be derived from endoscopic neurosurgery tools that can be used manually and via robot therefore, the potential to further develop these tools – can be designed for use with robotic surgery which is (give a number on how big robotic surgery is and a description of its niche)

Therefore, these tools can be used for neuro, sinus, ear, and more to come

**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.**

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