**Overview:**

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. An endoscope allows visualization of the middle ear 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 [2] [3]. SickKids Hospital remains one of the few centres in North America where a surgeon completes the majority of middle ear procedures endoscopically, due to the steep learning curve. The principle challenge with TEES is that a one-handed surgical technique is required while the endoscope is held in the other hand. Otologic instruments were developed for two-handed microscope-guided surgery so they are not optimized for TEES conditions [2] [4]. The team at SickKids has accumulated valuable insight into the strengths and weaknesses of currently available instrumentation for TEES through experience and observation of TEES. These shortcomings have hindered the use of TEES; this project will address them by engineering specialized instruments to facilitate TEES [4] [5].

**Aims:**

*Aim 1 (months 1-12, in progress).*To conduct a needs assessment survey, using the two-round Delphi method, that examines the current limitations of TEES and how to encourage its adoption. A questionnaire has been formulated from a literature review and interviews with local otolaryngologists. It has been sent to otolaryngologists globally and the first round of responses will be analyzed to develop the second questionnaire. A time flow analysis, recording the duration of surgical steps, is being conducted to quantify the limitations of the current instruments used in TEES, by assessing their efficiency. The team has acquired Research Ethics Board approval to conduct these studies and the results will be published to establish the requirements for training and instrument development to facilitate TEES.

*Aim 2:*An initial, functional prototype, developed by the supervisor and student, has been designed to access areas within the middle ear that are difficult to reach with current instruments. As well, an instrument to facilitate manipulation of a synthetic graft during ear drum reconstruction surgery has been prototyped. CT scans of patient anatomy are being used as a guide for designing optimal instrument geometry that can fit into the ear alongside the endoscope and perform the intended functions.

*Aim 3:* Validation testing will be conducted and published to compare existing tools to the new tool. Local ear surgeons will test the tool on cadaveric or 3D printed ear models by performing an ear drum reconstruction procedure whilst trying to reach hidden recesses behind the ear drum. The duration of the procedure will be measured to assess the efficiency, functionality and ease-of-use of the tool compared to the same procedure with existing tools. As well, qualitative feedback, in terms of ease of use and ergonomics will be obtained.

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

**Significance:**

The development of tools to facilitate endoscopic ear surgery aims to encourage more ear surgeons to adopt this minimally invasive surgical technique, which would reduce patient morbidity rates, recovery time and hospital stay [6]. Endoscopic ear surgery has been shown to reduce rates of residual skin growth after surgery in the middle ear as the endoscope allows greater visualization in the previously hidden recesses within the ear [7].

Further, new instruments will also be applicable to other minimally invasive surgeries within bony cavities such as in sinus, nasal, spinal and arthroscopic surgery [6] [8] [9]. Presently, we have an existing collaboration with minimally invasive neurosurgery. Additionally, the techniques developed to create new, specialized instruments could be used to create patient specific instruments by using virtual patient models and rapid fabrication methods developed in this work.

**Bibliography:**

[1] C. Carlos, W. Parkes, and A. L. James, “Application of 3-dimensional Modeling to Plan Totally Endoscopic Per-Meatal Drainage of Petrous Apex Cholesterol Granuloma,” pp. 3–4, 2015.

[2] A. L. James, “Endoscopic middle ear surgery in children.,” *Otolaryngol. Clin. North Am.*, vol. 46, no. 2, pp. 233–44, Apr. 2013.

[3] M. S. Cohen, L. D. Landegger, E. D. Kozin, and D. J. Lee, “Pediatric endoscopic ear surgery in clinical practice: Lessons learned and early outcomes,” *Laryngoscope*, p. n/a-n/a, 2015.

[4] M. Yong, T. Mijovic, and J. Lea, “Endoscopic ear surgery in Canada : a cross-sectional study,” *J. Otolaryngol. - Head Neck Surg.*, pp. 1–8, 2016.

[5] H. Kanona, J. S. Virk, and A. Owa, “Endoscopic ear surgery: A case series and first United Kingdom experience.,” *World J. Clin. cases*, vol. 3, no. 3, pp. 310–7, 2015.

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

[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.

[8] “AANS - Minimally Invasive Spine Surgery MIS.” [Online]. Available: http://www.aans.org/patient information/conditions and treatments/minimally invasive spine surgery mis.aspx. [Accessed: 17-Nov-2015].

[9] “Endoscopic Nasal & Sinus Surgery.” [Online]. Available: http://care.american-rhinologic.org/ess. [Accessed: 17-Nov-2015].