Needs Analysis and Time Flow Study to Assess Endoscopic Ear Surgery

**Introduction:**

Minimally invasive surgery is a technique that 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, minimally invasive ear 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 advantages of endoscopic ear surgery are as follows: removing the need for an external incision and reducing post-operative morbidity (10), improved outcomes by enhancing minimally invasive access for disease eradication (2-4), more effective disease control as shown by the reduction of the rate of reoccurring skin growth (2, 3), and better hearing due to hearing bone preservation (10, 11).

Despite the enthusiasm of some ear surgeons (otologists), endoscopic ear surgery has not as yet been accepted by all practicing otologists (5). 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 the TEES environment [3]. As otologists have been trained and gained experience in microscope-guided ear surgery, they have developed techniques with the according instruments and have become accustomed to a two-handed surgical approach. By learning different surgical techniques and gaining experience with the endoscope, most surgeons find that they can complete more cases endoscopically (1, 7, 12). Nevertheless, the learning curve can be slow and frustrating. In the experience of the primary investigator (PI), technological advances in the design of the endoscope, camera and suction dissection instruments have lead to incremental stepwise jumps in this learning curve (13). Therefore, the potential for improving TEES experience lies in instrumentation and training of surgeons.

**Research Question:**

Why is TEES not widely adopted by otologists and what technological advances would encourage more frequent and broader use of TEES.

**Hypothesis:**

We hypothesize that a needs analysis study will provide an answer to this question and help develop criteria against which new endoscopic ear surgery tools can be developed.

**Objective:**

In order to increase the use of TEES, this project’s objective is to understand the reason for surgeons not adopting TEES, and the limitations of existing tools, by conducting a needs analysis. This information will be used to develop design criteria against which future instrumentation and training models can be developed to facilitate practitioner use of endoscopic ear surgery.

**Study Rationale:**

*Time Flow Analysis:*

Time flow studies aim to analyze the efficiency of procedures, and have been used for many purposes in surgery. Rube et al. Recorded the time for MRI-guided angioplasty and assessed the efficiency and feasibility of the proposed workflow and framework for this type of procedure [4]. Similarly in an attempt to show the efficiency of a dedicated minimally invasive operating room (OR), Hsiao et al. recorded the time for steps during laparoscopic procedures in two types of OR’s: a dedicated minimally invasive OR and a traditional OR [5].

This study will also assess the feasibility and efficiency of endoscopic ear surgery using the same method: recording the times of steps in the procedure. This will aim to determine the inefficiencies and address the steps where further instrument design would be beneficial. This would also provide a good benchmark against which to measure efficiency and feasibility of future tools that would be developed.

*Survey:*

Surveys, consisting of questionnaires, are used to gain information regarding a specific topic by consulting a wide variety of experts in the field. Marcus et al. assessed the technical challenges of endoscopic neurosurgery and the scope for technological advances that would overcome the challenges by asking members of the Society of British Neurosurgeons to answer these questions in an online survey and analyzed using a multi-rater emergent themes analysis [6]. Therefore, this method has been used to gain knowledge in the field of endoscopic surgery and will be used in this study to answer similar questions.

*Existing Tools:*

Currently, only a limited selection of instruments is available for endoscopic ear surgery. One set of instruments, known as the IWGEES set (Karl Storz GmbH & Co. KG; Tuttlingen, Germany) was developed from the work of Thomassin (9). From discussions with the PI and his colleagues, the following are limitations of these instruments: narrow, occlusion-susceptible suction tubes, inability to reach requisite recesses within the ear, and suboptimal tip design to perform the necessary functions. An innovative set developed by Panetti (13) incorporates suction into dissection instruments with an ingenious rotating connector (Spiggle & Theis Medizintechnik GmbH; Burghof, Germany). The ability to clear blood from the operating field is an advantage to the tools, however, the following limitations exist: inaccessibility of the thumb to suction control while manipulating the instrument, inappropriate tip design, suction not reaching the tip of the instrument, longer curved dissectors lacking the delicacy required for small recesses.

This project will aim to assess these limitations, including input from a variety of surgeons, and develop design criteria to improve the instrumentation.

**Specific Aims and Methods:**

The needs assessment will comprise two separate parts: (a) a time-flow analysis in the operating room of the PI and (b) a survey of endoscopic ear surgeons’ experience.

*Specific Aim 1: Time Flow Analysis:*

The time flow analysis will measure the duration of predetermined steps during the surgery as well as the number of changes between instruments. This will breakdown and quantify the period of time associated with the completion of a particular task; it is used across a variety of fields, including medicine (14). This will aim to measure the efficiency of current endoscopic ear surgery and provide areas where instrumentation redesign is required. The time flow analysis will be recorded by the MASc. student during ear surgery. these will be divided into preparation, tympanomeatal flap elevation, access to tympanomastoid sub-sites for cholesteatoma removal, graft positioning, and ossiculoplasty. The type of instruments used during these different maneuvers and the number of changes between different instruments will also be noted. These observation will also lead to an appreciation of the ergonomic requirements of instruments during otologic survey and the design advantages of different instruments for specific maneuvers.

It is anticipated that variance in time-flow between cases will be high between cases based on patient specific factors such as extent of bleeding, ear canal morphology, extent of disease. Nevertheless, this methodology will provide a more accurate assessment of surgical practice and challenges than anecdotal surgeon’s recall. Steps demanding a disproportionate amount of time or multiple changes in instrument will be determined from analysis of these data. This will reveal procedural areas in which surgical efficiency may be improved by instrument modification.

*Specific Aim 2: Survey:*

b) Survey.A qualitative assessment of the challenges in endoscopic ear surgery caused by limitations in current instrumentation will be completed by performing an on line survey of surgeons that perform endoscopic ear surgery. The Delphi method will be followed to analyze the qualitative results of the survey. A preliminary survey for local otolaryngologists, with varied experience in TEES within the University of Toronto, will develop a questionnaire. Questions will ask for comments on factors that have prevented otologists from using endoscopes in otologic surgery, and for comments on the perceived strengths and weaknesses of currently available instruments for endoscopic ear surgery. The survey will then be sent, via email, to many otologists around the world, including the 60 members of the International Working Group on Endoscopic Ear Surgery (IWGEES) (http://www.iwgees.org) plus delegates that have attended courses organized by the PI and consenting members of the IWGEES. The answers will be analyzed to develop a third survey that will be sent out once again to the participants. This will attempt to develop a consensus of conclusions for the survey.

The confidential survey will be provided electronically using FluidSurveys, an online survey tool (http://fluidsurveys.com). A consent form will be attached with the survey.

**Expected Outcomes:**

From the PI’s personal experience and prior communication with IWGEES members and participants of Endoscopic Ear Surgery Conferences worldwide, it is anticipated that the following challenges and needs will be revealed: difficulty clearing blood from the field, difficulty retracting soft tissue flaps during dissection, visualization of deeper recesses of the middle ear cleft by the endoscope but inaccessible by current instruments, difficulty with bone removal beyond certain anatomy, and difficulty with ear drum graft positioning.

Factors such as these will be combined with emphasis given to those reported most frequently by survey respondents to generate a list of requirements for improvements in endoscopic surgical instrumentation. The list of requirements from the survey will be combined with the summary of the time-flow data to determine areas of greatest need for instrument improvement.

Surgeons previously contacted for the survey will be sent copies of the findings and invited to offer suggestions for improvements in instrument design. It is anticipated that the response rate to this request may be low as surgeons may be protective of their own ideas, but may still help to generate some innovative solutions. Any solutions offered will be combined with concepts already developed by the research team to generate innovative designs for novel instrumentation. The strengths and weaknesses of current otologic instruments will be included in this review and attention paid to combining functions of current instruments into single tools that can be simply operated with one hand.

This methodology will collect insight from a variety of surgeons, however, a potential limitation would be a lack of adequate or representative responsiveness from survey participants. However, the creation of practical and innovative solutions to the challenges of endoscopic surgery is not dependent upon a high survey response rate. Having taught at multiple surgical courses, participated in seminars, attended endoscopic conferences around the world, and by associating with other leaders in the field, the PI has considerable insight into the current status of activity and opinions within the field of endoscopic ear surgery.

**Significance**

Understanding the needs for TEES in order to design instruments better suited for the surgery aims to encourage surgeons to adopt endoscopic ear surgery.

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 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 [1], [7], [8]. It could be envisaged that ultimately, virtual patient models could be used with rapid prototyping and fabrication to create patient specific specialist instruments so extending the limits of minimally invasive surgery even further.

**Abstract**: background, methods, results, conclusions, keywords: questionnaire, survey, endoscopic ear surgery

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

[2] 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.

[3] 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.

[4] M. A. Rube, F. Fernandez-gutierrez, B. F. Cox, B. Holbrook, J. G. Houston, R. D. White, H. Mcleod, M. Fatahi, and A. Melzer, “HHS Public Access,” vol. 10, no. 5, pp. 637–650, 2015.

[5] K. C. Hsiao, Z. Machaidze, and J. G. Pattaras, “Time Management in the Operating Room : An Analysis of the Dedicated Minimally Invasive Surgery Suite,” pp. 300–303, 2004.

[6] H. J. Marcus, T. P. Cundy, A. Hughes-hallett, Z. Yang, A. Darzi, D. Nandi, and D. Phil, “Europe PMC Funders Group Endoscopic and Keyhole Endoscope-assisted Neurosurgical Approaches : A Qualitative Survey on Technical Challenges and Technological Solutions,” vol. 28, no. 5, pp. 606–610, 2015.

[7] “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].

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

[9] A. L. James, “E n d o s c o p i c Mi d d l e E a r S u r g e r y in C h i l d ren,” *Otolaryngol. Clin. NA*, no. November, 2012.

[10] A. L. James, B. C. Papsin, and B. C. Papsin, “-- Head and Neck Surgery,” no. September, 2012.

A good background information article is: [9]

* Endoscope allows assessment of ear drum in clinic and minimally invasive access to the middle ear for surgical procedures, and is a great teaching tool as you can record endoscopic images and there is a large screen so people can see
* Endoscope allows effective cholesteatoma while preserving the hearing bones (ossicles) and tympanic membrane and reduces residual cholesteatoma
* An external incision is avoided which provides relief for parents, same day discharge and lower morbidity (find an article stating lower morbidity)
* Allows panoramic view of middle ear cleft
* Requires training and resources
* Adult size and size of middle ear and tympanic membrane are approximately similar, so tools of the same size can be used for both types of surgery
* Most common procedures done endoscopically: tympanic membrane perforation reconstruction and cholesteatoma, but in children cholesteatoma reaches deep into the mastoid which is beyond the limits of totally endoscopic permeatal approach

Use this article when talking about tympanoplasty and considerations for time flow study [10]