

Understanding the Limitations of Current Surgical Tools to Develop Better Instrumentation to Facilitate Minimally Invasive Ear Surgery

Background: Transcanal endoscopic ear surgery (TEES) is a new and growing field that allows surgeons to perform common ear surgeries such as ear drum reconstruction, cholesteatoma (skin growth) removal and hearing bone repair through a natural body opening, the ear canal [1]. Alternatively, traditional microscope-guided surgery is much more invasive requiring a skin incision and often removal of bone behind the ear. By comparison, the endoscopic approach allows for better visualization, more effective cholesteatoma removal and the preservation of the hearing bones [2]. TEES reduces the length of hospital stay, overall procedure cost and significantly improves cosmesis, which is very important to patients [3]. However, with all of these benefits, a survey of 80 Canadian otologists (ear surgeons) reported the adoption rate of TEES as less than 10% [4]. Although, the literature has not yet reported specific reasons for this low adoption. One possible explanation is that existing instruments are developed for two-handed microscope-guided surgery and are not optimized for one-handed TEES, making the surgery challenging.

Objectives and Hypothesis: The objective of this study is to investigate otologists' preferences concerning the use of TEES, with a focus on the limitations of existing tools. I hypothesize that instruments are not optimized for TEES and to show this, I will conduct a needs analysis survey, and a surgical time-flow analysis of expert otologists. I aim to identify existing instrument limitations to allow development of new tools to facilitate the application of TEES for patient benefit worldwide. 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, to facilitate safer and more effective middle ear surgery in Canada [5].

Aims and Methods:

Aim 1 (months 1-9): A needs assessment survey, sent to 100 otologists internationally, will follow a two-round Delphi method to identify trends and limitations for surgeon adoption of TEES. The questionnaire has been developed based on local otologists' feedback on TEES. The questionnaire's resulting qualitative scores will be analyzed using non-parametric tests and ANOVA to develop a second survey with more specific questions to identify distinct criteria that define the limitations of instruments and needs of surgeons using TEES.

Aim 2 (months 1-9): A time-flow analysis study will record the duration of surgical steps for common TEES procedures. It will be conducted by observing a total of 50 surgeries performed by five surgeons at The Hospital for Sick Children, Toronto. This data will quantify the efficiency of current tools, and determine steps where innovation in instrument design is required to ease the surgery.

Aim 3 (months 3-5): A task-space analysis study will record the tip motions of existing TEES instruments. The measurements will be collected at the CIGITI lab, at The Hospital for Sick Children, while an experienced otologist simulates safe ear surgery maneuvers inside of 3D-printed ear canal models. The data will be recorded using a micro-scale electromagnetic sensor that will map how the tools move. The 3D ear-canal models are being developed from CT scans of patients who are candidates for TEES surgery. This study will help quantify the interaction between the geometry of instruments, anatomy of the patient and the ergonomics of the surgeon. This will provide a platform for developing novel instrumentation with improved functionality within the constraints of the ear canal.

Significance: These studies will identify limitations of existing instrumentation at different levels, and will provide criteria for the development of novel, safe and efficient TEES tools which will be disseminated in otolaryngology publications. As well, in collaboration with other minimally invasive tool innovation at CIGITI, a functional prototype instrument was designed and tested by the supervisor and student to facilitate ear drum reconstruction surgery. Thus, this project represents a valuable collaboration within minimally invasive tool development research. The new instruments will aim to facilitate minimally invasive TEES which would thereby reduce surgical morbidity, length of hospital stay and associated costs to ensure patients can return to their normal lives safely.

References:

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