**Development of Surgical Instruments for Endoscopic Ear Surgery**

**Background:**

Imagine a world where all surgeries are performed minimally invasively, a technique that reduces trauma to the body, scarring, recovery time and length of hospital stay [1]. Middle ear surgery is performed traditionally via microscope, which requires an external incision, or with an endoscope, which is minimally invasive, achieves similar results, and does not require an external incision [2, 3]. In transcanal endoscopic ear surgery (TEES), an endoscope travels through the ear canal and provides visualization for the surgeon to perform middle ear surgeries such as ear drum reconstruction, skin growth removal and hearing bone repair [2]. These surgeries require instruments that are able to grip and manoeuvre objects as well as access hard to reach areas within the middle ear [2, 3].

TEES requires one-handed surgery, extensive training and does not have specialized instruments that enable grip, maneuverability and accessibility in TEES conditions [3]. 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 [4, 3].

**Objectives and Hypothesis:**

To develop surgical instruments that ease one-handed surgery and reduce required training for TEES. To achieve this, tools will be designed to improve grip and manoeuvrability of synthetic grafts and enable accessibility in hard to reach places within the middle ear. Increasing functionality of surgical instruments, by manipulating angular geometry, adding pushing mechanisms and adding suction capabilities, will increase control during TEES, thereby easing one-handed surgery and reducing required training.

**Experimental Approach:**

Development of the tools will follow an iterative engineering design process. Initial prototypes will be 3D modeled on Solidworks and fabricated by 3D printing or machining, such as CNC or mill machining, and tested on 3D ear models. Test results will drive further iterations of the design and functional prototypes will be designed for machinability to produce final prototypes.

**Methods/Procedures:**

To achieve the desired functionalities, prototypes will: use suction capabilities to grip objects, employ spring-loaded or track-guided mechanisms to push objects off the instrument, and manipulate angular geometry to achieve accessibility. 3D instrument models will be integrated with 3D ear canal models, constructed by manipulating CT scans, to optimize dimensions and angular geometry. As well, existing instruments that enable grip, such as the T-Tube inserter and alligator forceps, will be incorporated in prototypes to provide gripping functionality [5, 6].

Prototypes will be tested by an ear surgeon on a 3D printed ear canal with an endoscope and a synthetic graft, to assess improvements in grip, maneuverability and accessibility. Engineering drawings of functional prototypes will then be drafted for professional machining of the instruments.

**Significance of Proposed Research to Biomedical Engineering:**

Developing instruments specialized for use in TEES would ease one-handed surgery, reduce required training and thus enable more surgeons to adopt this minimally invasive technique. Further applications of the tools for minimally invasive surgery include sinus, nasal, spinal and gynecological surgery that also require instruments with grip, maneuverability and accessibility [1, 7, 8]. Thus, reducing patient risk, recovery period and hospital stays for additional types of surgery.

**Further Improvements:**

After functional development, final prototypes would be designed for manufacturability and sterilization. A longer term goal would be the integration of multiple functionalities to have multifunctional tools. This would reduce surgical time even more by reducing the number of times the surgeon has to switch between instruments.

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