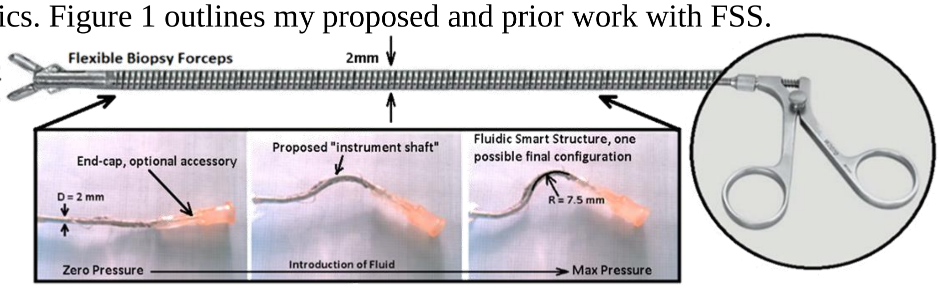
Background: Standard surgical instruments used in treating post traumatic cerebrospinal fluid (CSF) leaks, a serious associated complication of traumatic brain injury (TBI), are inadequate. Current tools lack the required size, dexterity and reachability needed to suture facial grafts in the anterior skull base, leading to reoperation. Procedures remain technically challenging, increasing surgeon fatigue, operative time and errors. Further, miniaturizing classic technologic solutions from laparoscopy to address this need approaches the limits of manufacturing. The **goal** of this work is to **reduce the burden of TBI** by designing easy to use, cheap, effective, customized instruments to better target hard to access CSF leaks. This work **aligns with a CIHR strategic initiative** for "clinical research…across the **full spectrum of TBI injuries"** and the "**translat[ion]** of…research findings into **improved health products**…**and tools**."[t] **Fluidic smart structures** (FSS) are silicone and metal composite devices with regions of differing stiffness that change shape when pressurized with saline. Constructing instrument shafts from FSS can produce novel, robust, reconfigurable and complex tool shapes with minimal user effort and without the need for electronics. Figure 1 outlines my proposed and prior work with FSS.

Figure 1: Fluidic Smart Structure with tailored geometry to create custom tool shaft shapes better suited to reach difficult sites. Shape varies with applied pressure as saline or water is injected into the structure



Objectives & Hypothesis: To develop an interventional tool using smart materials and structures, with engineered physical and structural properties, for improving surgical outcomes related to the treatment of **post traumatic CSF leak**. Since anterior sinus CSF repair is technically challenging; I **hypothesize** that custom instrument shafts built from FSS, designed with shapes optimized according to patient imaging, will reduce procedure time and achieve equal clinical outcomes compared to standard tools.

Aim 1: Quantify anatomic variability (0-6 months): A retrospective review of MRI images of traumatic CSF leakage will produce a statistical library of relevant anatomy to guide the design of custom tool shapes. Complying with research ethics protocols, the surgical workspace volume for a minimum of 15 patient cases with anterior skull base defects will be represented by a set of 3D points. Experts will select points of interest and outline a trajectory starting from the surgical incision for ergonomic obstacle avoidance. I will use least squares minimization to fit a path to the data, creating "space curves." These new measurements add to our <u>quantitative</u> understanding of skull base anatomy

Aim 2: Optimize smart structure (6-19 months): A set of FSS will be synthesized with varying structural and material properties, yielding an understanding of how to tailor the final instrument configuration to match the space curves of **Aim 1** and reduce the difficulty of reaching the operative site. I will model the relationship between fluid pressure and curvature using lumped analysis continuum mechanics. I will then produce sets of FSS forceps and scissors similar to standard tools.

Aim 3: Establish efficacy *in vivo* (19-36 Months): I will administer an established animal model for CSF leakage to compare the candidate instruments from **Aim 2** to standard tools. This study will consider: total operative time, time for site preparation, time for graft placement and surgeons' qualitative Likert based rankings of ergonomics and workflow. Graft placement success will be quantified with *ex vivo* burst tests and histology. The procedure will be conducted according to the Animal Care Committee with 2 groups of 5 animals randomly assorted into the FSS or control group.

Conclusion: This technology will better treat post traumatic CSF leaks, addressing a complication of TBI, the leading cause of death and disability for Canadians under the age of 45. FSS are cheap, readily available and can be added into standard instruments. They reduce the awkwardness of reaching the operative site and maintain the current surgical workflow for a seamless transition into practice and benefit the field of neurosurgery as a whole. **Reference:** [t] CIHR; www.cihr-irsc.gc.ca/e/45665.html