Multidisciplinary Research Program in Medicine Project*: Evaluating the role of transcervical 3D ultrasound imaging of the oropharynx during transoral robotic surgery*

Hypothesis or Research Question(s): We hypothesize that transcervical 3D ultrasound and magnetic resonance imaging can accurately assess oropharyngeal anatomy and pathology with a high degree of accuracy.

PROJECT BACKGROUND & SUMMARY

Rationale/context Oropharyngeal squamous cell carcinoma (OPSCC) is one of the most common types of head and neck cancer that affect thousands of Canadians every year. Historically, OPSCC has managed with chemoradiotherapy; however, in recent years, transoral robotic surgery (TORS) has risen as a minimally invasive alternative technique that results in similar oncologic and functional outcomes. During TORS, the surgeons operate the robotic arms through a remote console and visualize their surgical field through a camera arm. Thus, a limitation of robotic surgery is that haptic feedback and 3D visualization of the patient's anatomy is lost. A feasible solution is the use of ultrasonography, which can enhance and improve the outcomes of TORS by guiding physicians in identifying tumor margins and critical neurovascular structures. Although 3D ultrasound imaging has been demonstrated to enhance visuo-spatial orientation and improve resection margin rates of robotics prostatectomy surgery, its usage for OPSCC has not been reported on.

Hypothesis/methodology The goal of this project is to assess the utility of intraoperative 3D ultrasonography of the oropharynx (OUS) in patients undergoing TORS. TS will be involved in the data collection and image registration steps of the project. Patients presenting with OPSCC and undergoing TORS will be recruited to the study. 3D OUS images will be collected and compared to other imaging modalities (CT, MRI, PET scans) for tumor volume, tonsil volume, artery position, and muscle position. As well, 3D OUS will be segmented using deep learning algorithms by TS. The segmentation will be registered to the patient's preoperative MRI and displayed on the surgical robotic console to allow for better perioperative visualization of the surgical field. This integrated system will be evaluated in OPSCC patients using both subjective (surgeon-reported feedback), and objective measures (evaluation of anatomical landmark relative positions, tumour volume, and margin). TS's work will be crucial in allowing for clinical testing of the efficacy of 3D OUS in TORS for OPSCC.

Feasibility/timeline The feasibility of OUS to visualize oropharyngeal anatomy has been demonstrated in a pilot study with 10 patients prior to the start of the SSRP project. The next steps of the project are to apply OUS in the surgical setting with the same 10 patients. During the 8-week length of the SSRP project, TS will perform the segmentation using deep learning and investigate landmark-based registration of OUS to MRI.

Expected outcomes It is expected that the 3D OUS can accurately detect anatomical structures intraoperatively compared to other imaging modalities currently used for OPSCC detection. As well, registration of OUS to MRI can be performed with minimal accuracy errors. The use of the overlaid images is expected to enhance the surgeon's experience.

BENEFIT TO THE STUDENTS

We plan to recruit one or more Clinical Research Assistants and one or more R&D Engineering Research Assistants. Each of the student's (TS) roles are outlined below.

Clinical Research Assistant:

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1. Assist the PI and other members in formulating the hypothesis for the study

2. Design quantitative metrics for assessing the effectiveness of 3D OUS in TORS as reported by the surgeon

3. Perform chart review on participants' demographic, clinical, surgical, pathological, and radiological data

4. Administer questionnaires to collect patient-reported outcomes

5. Interpret findings from statistical analysis of raw data

6. Present at weekly research meetings and national and/or international head and neck surgery and/or medical robotics conferences

7. Prepare final report to study committee on the outcomes collected, including but not limited to, critical literature review and analysis of current findings of studies involving 3D OUS; feasibility of 3D OUS in detecting anatomical structures during TORS; any potential changes to be made to the study protocol or primary/secondary outcomes; data collected during the project

R&D Engineering Research Assistant:

1. Assist the PI and other members in formulating the hypothesis for the study

2. Analyze intraoperative 3D OUS images

3. Compare different deep learning algorithms to determine the optimal technique to segment anatomical structures

4. Register 3D OUS images onto pre-operative MRI images to generate a real-time augmented reality scene and display the result in the surgical robot window

5. Present at weekly research meetings and national and/or international head and neck surgery and/or medical robotics conferences

6. Prepare final report to study committee on the outcomes collected including critical literature review and analysis of current findings of studies involving 3D OUS, feasibility of 3D OUS in detecting anatomical structures during TORS, and any potential changes to be made to the study protocol or primary/secondary outcomes

Overall, TS will gain a deeper understanding of TORS and medical robotics technology and clinical research in the context of OPSCC. From the tasks described above, TS will gain the following skills:

1. A deeper understanding and technical proficiency in the usage of 3D OUS in TORS, an important skill that is directly transferable to other research projects involving medical technology

2. Familiarity with da Vinci medical robot through dynamic registration of 3D OUS to MRI and augmented reality scene display

3. Further practice programming skills in Python and related data analysis software packages

4. Experience working with medical imaging (CT, MRI, 3D OUS)

5. Familiarity with conducting chart reviews to extract clinical data

6. Effective research communications with both research personnel who is familiar with the student's work and research methodology (in weekly meetings) and fellow researchers who may not be as familiar with TORS and the specific techniques used in the project (at conferences)

7. Gain technical writing skills by preparing an abstract and/or manuscript summarizing the main findings of the study

8. Network with research and medical professionals including the PI and laboratory members consisting of engineers, graduate students, engineering research collaborators, clinical coordinator, etc. and members of the head and neck/medical robotics research community

9. Critical analysis of research articles; evaluate whether the data collected during the project support or reject the hypothesis that 3D OUS can be used to enhance the surgeon experience in TORS and improve the accuracy of tumour volume and anatomical structure segmentation; scientific writing via internal report to the trial committee

Resources available: TS will be mentored by both the PI and co-supervisor, who are experienced researchers in the field of medical robotics and head and neck surgery. TS will have access to graduate students, clinical fellows, postdoctoral fellows who will provide further guidance in the technical aspects of the project (programming, data analysis, etc.)