Adapting electromagnetic tool tracking for ultrasound-guided oral cavity cancer resection

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INTRODUCTION: The surgical excision of tongue tumors, referred to as glossectomy, is a common treatment for oral tongue cancers. The procedure involves excising the tumor while preserving as much of the surrounding healthy tissue as possible. The excised tongue tumor is sent to a pathologist to analyze the tissue, negative margins indicate that the tumor was sufficiently removed from the patient [1]. The computer-navigation system, *NaviKnife*, uses real-time electromagnetic tracking to determine the location of the surgical tools relative to the patient anatomy, originally developed for breast-conserving surgery. When tested the system resulted in the resection of less healthy tissue as well as increased confidence for the surgeons [2]. In this work, we present the technical challenges and potential solutions when translating previously designed computer navigated systems to glossectomy.

METHODS: The *NaviKnife* system was initially tested for glossectomy by directly applying it to a simulated workspace (Figure 1). However, implementing *NaviKnife* in its current iteration within the glossectomy workspace posed a series of challenges that must be solved. The first challenge comes from the constrained glossectomy workspace. Due to the minimal workspace within the operating room the *NaviKnife* tumor tracking methods must be compact to prevent it from disrupting the surgeon while maintaining a high accuracy. Another issue is the complex anatomy of the tongue, as it has the lingual artery which if breached can cause excessive bleeding. The current standard for tracking tumors within *NaviKnife* is to use ultrasound imaging to generate a 3D visualization in the navigational software, while inserting a tracked needle within the tumor. This could pose challenges for the surgeon if the lingual artery is pierced causing complications for the patient.

Figure 1: Experimental glossectomy workspace utilizing the *NaviKnife system*.

RESULTS: The standard electromagnetic tracking elements used for *NaviKnife* while effective for operations with larger workspaces are too large and bulky for use in glossectomies. The tracking methods must be redesigned to prevent disrupting the surgeon and harming the surrounding anatomical structures within the tongue. A potential solution includes implementing a small sensor which can be inserted directly within the tumor to be tracked instead of using a tracked needle (Figure 2). Due to the small nature of the sensor, it will prevent overcrowding in the surgeon's workspace during the procedure.

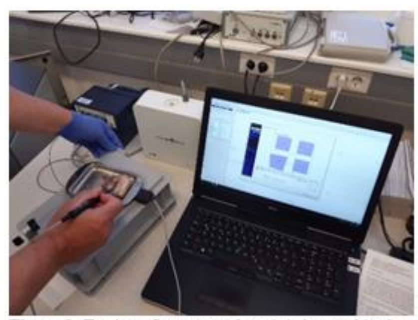

Figure 2: Testing of a sensor where it is inserted in tissue within a simulated working environment.

CONCLUSION: The study captures the complexity of implementing computer navigation within a constrained workspace. Within such a workspace the tracking techniques must be reinvented to allow comfortable non-invasive tracking. Future work includes comparing different tracking elements to determine their performance in a given workspace. Determining new methods for tracking within different surgical contexts that hold unique constraints may allow for the simple translation of existing computer navigation systems to different surgical fields.

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