Intraoperative Ultrasound in Oral Tongue Cancer Resection: Feasibility Study and Early Outcomes

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Sponsorships or competing interests that may be relevant to content are disclosed at the end of this article.

Abstract
The current standard of care in oral tongue cancer surgery is to determine the lesion’s dimensions by manual palpation and plan for resections allowing for a gross 1-cm clearance at all margins.1 While this method is often successful at determining the mucosal margins of the lesion, it is limited when attempting to determine the status of the deep margin. A number of studies suggested that ultrasound is superior to manual palpation and other imaging modalities (computed tomography, magnetic resonance imaging) at demarcating the margins of tongue lesions. Over the past 20 years, there have been several investigations into its utility as an intraoperative tool to visualize the deep margin in real time and plan resection margins.5-7

Herein, we relay our initial experience with the use of intraoperative ultrasound as an adjunct to oral tongue cancer surgery, reporting the feasibility of its use and our deep margin outcomes.

Methods
Study Design
Intraoperative ultrasound assessment of tumor deep margin distance was introduced as a pilot clinical innovation and a modification of a previously reported technique6 in a continuous series of previously untreated patients undergoing partial glossectomy under the direction of a single surgeon. This retrospective review was approved by the Institutional Review Board of the Massachusetts Eye and Ear Infirmary. For this report, patient data were extracted from the medical records, including age, sex, tumor stage (pathologic), sonographic tumor thickness, histologic tumor thickness, histologic deep margin clearance (mm), and histologic evidence of invasion (lymphovascular/perineural).

Surgical Procedure
Standard intraoperative assessment of the surgical margins was employed among all patients in this series. Peripheral resection margins were marked, allowing 1.0 to 1.5 cm of...
gross clearance to account for the expected 30% shrinkage on final fixed pathologic analysis and a target final margin >5 mm (Figure 1A). Digital palpation of the tumor was then performed to determine an estimated depth of invasion. A broadband compact linear array ultrasound transducer (L15-7io; Phillips) enclosed in a sterile plastic cover was introduced into the surgical field, placed on the surface of the target lesion, and swept over the lesion in anterior-posterior and medial-lateral directions (Figure 1B). The deep margin was identified and a sonographic measure of the tumor thickness attained (Figure 2A). Effort was made to obtain at least 1.0 cm of gross deep clearance. As the procedure progressed from anterior to posterior, at the midpoint of the resection, the deep margin was evaluated with manual palpation and confirmed with the ultrasound probe (Figure 2B). At the conclusion of the procedure, the probe was used to interrogate the resected specimen and verify the deep margin distance (Figure 2C). The entire specimen...
was taken to the frozen section laboratory and oriented by the surgeon. Selected microscopic frozen sections were obtained from the specimen as the standard practice for the surgeon involved. The remaining tissue was submitted for routine analysis.

**Results**

Twelve patients are included in this series; all procedures were successfully completed with no complications related to the use of the ultrasound. Table 1 summarizes sonographic and histologic measures of tumor thickness, as well as the closest distance to the deep margin on formalin-fixed pathology for each patient. Mean ± SD deep margin clearance on paraffin-fixed specimens (Figure 2D) was 9.71 ± 1.18 mm.

**Discussion**

Herein we report our initial experience obtaining intraoperative ultrasound images during transoral resection of tongue cancer with the objective of consistently obtaining an adequate deep margin. We were able to visualize the deepest point of invasion in all 12 cases, corroborating our intraoperative manual assessments. Our average deep margin measurement met our standard target. The method of intraoperative ultrasound added little time and risk to the procedures, confirming feasibility and suggesting that this may be a valuable tool for intraoperative management of tongue cancers.

We are aware of 3 other published studies that describe the use of ultrasound in this operative setting. Helbig et al\(^5\) reported a series of 5 cases in which sonographic images were used to visualize the deep margin and a braided surgical suture was used to mark 1 to 2 mm of distance from the deep margin of the tumor and aide planning of the surgical resection. Baek et al\(^6\) and Kodama et al\(^7\) both conducted prospective studies where they used ultrasound guidance to drive needles deep to the tumor to mark the depth of resection, concluding that the method provided better assurance regarding the adequacy of the deep margin of resection. Our study is the first to report the use of ultrasound intraoperatively without the use of an invasive method to mark the resection/tumor margin.

Intraoperative ultrasonic imaging is not perfect. As of yet, we have not achieved strong correlation of histologic and ultrasound estimates of depth of invasion in all cases. Other disadvantages associated with this approach include (1) the potential for prolonged operative times related to preparing equipment and procuring image data and (2) the availability of ultrasound equipment and expertise. Furthermore, (3) the degree of compression of the tissue interface with the ultrasound probe is operator dependent and may lead to discrepancies in the reporting of tumor thickness during postresection evaluation.

**Conclusion**

Our preliminary report confirms the safety of this approach and suggests that ultrasound has the potential to improve our ability to obtain a clear, deep margin based on more objective assessment. Larger prospective controlled trials are needed to evaluate the effects of this approach on margin status and long-term functional/oncologic outcomes.

**Author Contributions**

Osama Tarabichi, conception, design, execution and analysis, drafting, revision and approval; Vivek V. Kanumuri, design, execution and analysis, drafting, revision and approval; Amy F. Juliano, execution and analysis, drafting, revision and approval; William C. Faquin, execution and analysis, drafting, revision and approval; Mary E. Cunnane, execution and analysis, drafting, revision and approval; Mark A. Varvares, conception, design, execution and analysis, drafting, revision and approval.

**Disclosures**

Competing interests: Vivek V. Kanumuri, National Institutes of Health T32 Training Grant.
Sponsorships: None.
Funding source: None.

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