Rectangle Tongue Template for Reconstruction of the Hemiglossectomy Defect

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Objective: To determine if a rectangular template free tissue transfer is effective for the reconstruction of the hemiglossectomy defect.

Design: Prospective case series.

Setting: Tertiary care academic medical center.

Patients: A total of 13 patients (male to female ratio, 8:5; mean age, 55 years) presenting with squamous cell carcinoma of the oral tongue from May 2000 to December 2002.

Interventions: Of the 13 patients, 7 received postoperative radiotherapy and 2 received prior radiotherapy. The radial forearm was the donor site in 11 patients and the lateral arm and anterolateral thigh in 1 patient each. The mean flap area was 50 cm² (range, 24-80 cm²).

Main Outcome Measures: Major and minor complications, speech and swallowing assessment, oral cavity obliteration, premaxillary contact, tongue elevation, and tongue protrusion.

Results: There were no major complications, and 2 of the 13 patients experienced minor complications. Of the 13 patients, 12 achieved the goals of oral cavity obliteration and premaxillary contact and resumed solid oral intake. One patient remained G-tube dependent owing to toxic effects from previous chemoradiation treatment. The mean tongue tip protrusion was 0.7 cm (range, 0-1.7 cm), and the mean elevation was 1.7 cm (range, 1-3 cm). Patients with protrusion greater than 0.8 cm had better swallowing scores for “range of solids” (5.8 of 6 vs 3.9 of 6; P = .045) and “eating in public” (4.6 of 5 vs 3.5 of 5; P = .10). The average patient resumed a full range of liquid and solid intake with minimal restrictions and believed that their speech was mostly understandable with occasional repetition.

Conclusions: The template-based rectangle tongue flap effectively restored speech and swallowing function in this group of patients. Tongue protrusion greater than 0.8 cm is associated with better swallowing results.


RECONSTRUCTION OF THE tongue is necessary when oral cavity obliteration, premaxillary contact, and mobility will be impaired to an extent that normal swallowing and speech will be adversely affected.1 The need for reconstruction depends on the relative volume of the remaining tongue compared with the volume of the oral cavity, the expected scarring secondary to radiation therapy, and the resection of floor of mouth mucosa. Once the surgeon has made the assessment that there is insufficient remaining volume of the tongue to effectively obliterate the oral cavity, a flap reconstruction is necessary, particularly if swallowing function is to be maintained.2 It is relatively straightforward to design a reconstruction that effectively restores the volume of the missing tongue. It is less straightforward to design a reconstruction that maintains mobility of the tongue tip and retains the critical “finger function” of the tongue. It is the “finger function” that facilitates manipulation and shaping of the bolus and clearance of food particles from the labial and buccal sulci. In an attempt to optimize the residual “finger function” in a hemiglossectomy defect, there are a number of innovative approaches.3-6 It is difficult to compare these approaches, and there is no standard measure of functional outcomes. Our goal was to develop a reconstruction that maximizes the mobility of the remaining tongue tip and to develop a functional outcome measure that relates tongue function to speech and swallowing attributes.

METHODS

STUDY DESIGN
This prospective case series included 13 patients with major ablative defects in the oral cavity reconstructed by surgeons in the microvascular program of the Department of Oto-
PATIENT POPULATION

Patients were eligible if the defect, resulting from excision of squamous cell carcinoma of the oral cavity, consisted of a hemiglossectomy (no greater than one-half of the oral tongue in some patients with and some patients without tongue base involvement), and the reconstruction was performed using the template-based rectangle-shaped free tissue transfer. Based on clinical staging, 9 patients had T2 cancer, 2 had T3 cancer, and 2 had T4 cancer. The radial forearm was the donor site in 11 patients, and the lateral arm and anterolateral thigh were used in 1 patient each. Of the 13 patients, 12 (92%) are presently alive and free of disease. One patient died from distant metastases. There were 8 men and 5 women who met the inclusion criteria, with a mean age of 54.8 years (range, 29-71 years). The overall mean follow-up duration was 53.7 months (range, 22-76 months). All patients required ipsilateral lingual nerve resection as part of the hemiglossectomy. A microneural repair of the revascularized free tissue to the lingual nerve was performed in 5 of 12 patients (42%). Of the 13 patients, 12 (92%) underwent neck dissection: 11 (85%) underwent a selective neck dissection, and 1 (8%) underwent a modified radical neck dissection sparing the accessory nerve. Nine patients (69%) underwent radiation therapy; 7 (54%) underwent postoperative radiotherapy, and 2 (15%) underwent prior radiation therapy. Ten patients (77%) had defects consisting of an oral hemiglossectomy; 2 patients (15%) had a complete hemiglossectomy that included the base of tongue; and 1 patient (8%) had an extended complete hemiglossectomy that extended just past midline anteriorly. The mean flap area was 50 cm² (range, 24-80 cm²).

GOALS AND PRINCIPLES

Our general approach for hemiglossectomy reconstruction is to perform an anatomic reconstruction (Figure 1). The goals of hemiglossectomy reconstruction include the following:

1. Obliterate the volume in the oral cavity. Obliteration of the oral cavity is achieved when all oral cavity mucosal surfaces are in contact with one another when the mouth is closed. This goal is important because it should decrease the likelihood of food getting lost in a “dead space” in the oral cavity and improve the handling of secretions by bringing the revascularized free tissue transfer in contact with the remaining native mucosa.

2. Maintain premaxillary contact. This is an extension of the goal of obliteration of the oral cavity. In terms of speech generation, premaxillary and palatal contact are important for maintaining precision of articulation for a number of speech sounds. Generally, reduced precision of linguodental, alveolar, palatal, and velar sounds will occur if adequate contact is not achieved. The surgeon needs to ensure that when obliterating the volume of the oral cavity that some of the volume is concentrated anteriorly.

3. Optimize the residual “finger function” of the tongue. Finger function is the ability of the tongue to sweep and clear the buccal, labial, and alveolar sulci and protrude past the coronal plane of the incisors.

4. Maintain movement of secretions from the anterior to the posterior aspect of the oral cavity.

5. Optimize sensation of the remaining native tissue and the revascularized free tissue transfer.

To achieve these goals in hemiglossectomy reconstruction, we were guided by the following principles:

1. Careful flap selection to restore the volume of the defect. Overreconstruction of the defect volume is important because volume is slowly lost over years, particularly in patients who underwent radiation treatment.

2. Floor of mouth tissue is reconstructed with thin tissue, and tongue tissue is reconstructed with thicker tissue. This difference of tissue thickness is achieved by carefully choosing the position of the flap on the donor site or by customizing the flap. The flap is customized by either thinning the subcutaneous tissue in selected areas or by increasing bulk by folding over de-epithelialized subcutaneous tissue in other selected areas.

3. The volume associated with a mandibular defect and/or the muscles of the floor of the mouth is specifically addressed. The volume of these tissues, if resected, is restored to prevent the tongue reconstruction from contracting laterally or inferiorly, which compromises the goal of obliteration of the oral cavity.

4. The flap design and inset must allow anterior and posterior excursions of the tongue. This facilitates the protrusion of the tongue.

5. There needs to be a smooth gutter from the anterior floor of mouth to the posterior floor of mouth to facilitate the clearing of secretions. The reconstruction should not block the glossal, buccal, labial, or blink the labial-alveolar sulci.

SURGICAL APPROACH

The volume of the defect was estimated by evaluating 3 separate areas: the oral tongue defect, the musculature of the tongue deep to the axial plane of the floor of the mouth, and the body of the mandible. Because patients differ with respect to tongue size, mandibular height, and dental status, it is important to recognize that these varying dimensions all affect the volume that needs to be reconstructed. To assist in the estimation of the volume to be replaced, we use a surgical sponge and compress it into the defect. The volume can be estimated by compressing the same sponge into a volumetric cylinder and obtaining a measure. This measurement is used to harvest a flap of appropriate volume. If the patient has undergone radiation therapy or is likely to undergo radiation therapy, the additional volume is added to offset the volume that will be lost over the first year.

Three types of flaps were used in this series, all of which had the advantage of an axial pattern nerve supply to facilitate reinnervation. In a patient with a very low body mass index, a perforator-based rectus flap is an additional reconstructive option. The rectangle was sized by measuring the edges of the defect. The volume that will be lost over the first year.

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length was determined by measuring from the most dorsal and medial aspect of the defect to the tip of the tongue, while the tongue is gently placed on tension in the plane of the midline raphe. This forms the long, medial edge of the rectangle and is usually 8 to 9 cm (side A in Figure 2). Next, the width of the rectangle was determined by measuring from the tongue tip to the most anterior midline portion of the defect, while the tongue is gently placed on tension in a superior direction. This forms the shorter, anterior edge of the rectangle and is usually 3 to 6 cm (side B in Figure 2). Next, the width was verified on the rectangle by measuring from the posterior medial aspect of the defect, over the base of tongue, through the glossoptonsillar sulcus, and onto the lateral-posterior aspect of the defect (side C in Figure 2, which should be the same width as side B of the rectangle). Finally, the length of the rectangle was verified by measuring from the most posterior-lateral aspect of the defect, forward along the curvature of the mandible to the anterior midline portion of the defect (side D in Figure 2, which should be the same length as side A of the rectangle).

The template of the rectangle was placed on the donor site. In the forearm donor site, there is a fat pad overlying the brachioradialis with adjacent thinner skin of the flexor carpi radialis and palmaris longus tendons. The line of division between these 2 different tissue sites was used as the edge of the lateral tongue reconstruction. If more bulk was required for the tongue, additional subcutaneous tissue was harvested adjacent to side A and folded over to bulk up the lateral tongue. If additional volume was required for a large volume loss deep to the axial plane of the floor of the mouth or in the area of the body of the mandible, additional subcutaneous tissue was harvested over the brachioradialis pedicled off side C. There were 2 additional subunits (tabs) that were added, if resected, to the described rectangle tongue template. The first is a 2×1-cm tab located at the corner between sides C and D, which is oriented at a 45° angle and is used to resurface the retromolar trigone or the anterior tonsillar pillar. The second is a 2×1-cm tab, which extends parallel to side D by 2 cm to resurface the anterior floor of mouth.

The inset of the flap was performed in a segmental fashion similar to the method that was used to measure the template. The posterior aspect of the flap was tacked first. This was on side C, at the line of tension, to the most inferior portion of the glossoptonsillar sulcus. Next, the corner between sides A and C was tacked to the dorsum of the tongue at the most posterior superior aspect of the defect. The tongue was kept on gentle tension along the midline raphe. Next, the anterior corner between sides A and B was tacked at the tip. At this point, a determination was made as to whether the flap was draping properly into the tongue portion of the defect and adjustments were made. Then, 2 or 3 more tacking sutures were placed along the dorsum of the tongue. Next, the line of tension was created from the glossoptonsillar sulcus to the junction between the ventral tongue and anterior floor of mouth along side B. The line of tension was considered appropriate once the tongue portion of the reconstruction was pushed superiorly into the oral cavity and the dorsum of the tongue was aligned in an axial plane. This step would flip up the remaining flap tissue, which was used for reconstruction of the anterior and posterior floor of mouth along side D. This created a natural appearing glossomandibular sulcus along the inner table of the mandible. The closure was then completed along side C, side A, side B, and finally side D. Frequently, the anterior and posterior corners along side A needed a small amount of trimming to finesse the final result.

**OUTCOME MEASURES**

Outcome measures included major and minor complications, speech and swallowing assessment, oral cavity obliteration, pre-maxillary contact, tongue elevation, tongue protrusion, and post-treatment body mass index. Minor complications were defined as those that required treatment such as packing, drainage, or medication but did not require a procedure in the operating room or result in death.

The speech and swallowing assessment is a disease-specific, 6-item, administered questionnaire to evaluate post-treatment speech and swallowing ability (Figure 3). Two of the questions, pertaining to eating in public and understandability of speech, are validated questions derived from the Performance Status Scale for Head and Neck Cancer Patients (PSS-HN). The 4 nonvalidated questions pertain to the patient’s mode of nutrition, speaking in public, and range of liquid and solid intake. The Likert scale from the PSS-HN has been altered from a 25-point incremental scale starting at 0 and ending at 100 to a 1-point incremental scale starting at 1 and ending at 5, so that all questions use a 1- to 5-point or 1- to 6-point Likert scale (Figure 3). Functional outcomes were measured in all 13 patients at least 12 months after the completion of treatment (mean, 21 months [range, 12-45 months]).

**STATISTICAL ANALYSIS**

Univariate data were tabulated on radiation, defect, body mass index, sensation, complications, assessment of speech and swallowing, and measures of tongue mobility. Elevation-protrusion bubble plots, a form of scatter plots, were used. Tongue elevation was plotted on the y-axis and tongue protrusion was plotted on the x-axis for each patient. The patient’s score for each of the 6 speech and swallowing scales was attached to each point to visually determine if scores clustered in a meaningful way. Larger bubbles represented better (higher) speech and swallowing scores, and smaller bubbles represented poorer (lower) scores. Because the data were nonparametric, the Mann-Whitney test was used to compare the functional scores of patients above and below an elevation or protrusion cut point.

Of the 13 patients, 12 achieved the goals of oral cavity obliteration and premaxillary contact and were able to resume solid oral intake. The patient who did not resume oral intake underwent salvage surgery after chemoradiation treatment, was G-tube dependent prior to surgery, developed a tongue abscess after surgery, and was postoperatively reirradiated. This was the only pa-
The patient who was not able to achieve the goals of obliteration of the oral cavity and premaxillary contact.

The nutritional mode median score was 5 of 6. Of the 13 patients, 8 achieved a full score of 6 of 6, and all patients ate solids with the exception of the patient who was G-tube dependent prior to surgery. The “range of liquids” median score was 6 of 6. Ten patients achieved a full score of 6 of 6 with no restrictions. The “range of solids” median score was 5 of 6. Ten patients had minimal to no restrictions or required a liquid chaser to swallow the bolus. The “eating in public” median score was 4 of 5. Nine patients had no social restrictions or restricted diet when eating in public places. The “understandability of speech” median score was 4 of 5. Eleven patients were understandable all the time or required occasional repetition. Two patients believed that face-to-face contact was necessary for their speech to be understood. One of these 2 patients was a patient with alcohol-induced organic brain syndrome, and the second was the patient in whom the goal of oral cavity obliteration was not achieved. The patient with the organic brain syndrome reported consuming 6 to 12 drinks of alcohol per day and received a liver transplant within a year prior to the resection and tongue reconstruction. In the postoperative period after the liver transplantation, he had multiple small embolic cerebrovascular events. Two years after the tongue reconstruction, he experienced a fall that resulted in a closed head injury. He underwent a full cognitive assessment on 2 occasions, separated by a year, which showed that he functioned in the “impaired” range. The patient was included in the study because this study sample was sequential. The “speaking in public” median score was 5 of 5. Eleven patients had no restrictions to speaking in public.

The mean tongue tip elevation was 1.7 cm (range, 1.3-1.7 cm) and the mean tongue protrusion was 0.7 cm (range, 0.1-1.7 cm). The functional measures were bubble plotted against elevation-protrusion values to assess the ability of the rectangle tongue reconstruction to optimize the residual “finger function” of the tongue. Patients with a tongue protrusion greater than 0.8 cm had better swallowing-related scores, particularly in “range of solids” (5.8 of 6 for those with a protrusion >0.8 cm vs 3.9 of 6 for those with a protrusion of ≤0.8 cm; P=.045) and “eating in public” (4.6 of 5 for those with a protrusion greater than 0.8 cm vs 3.5 of 5 for those with a protrusion of ≤0.8 cm; P=.10). A clear cut point may not have been as evident with the elevation measure because 12 of 13 patients achieved obliteration of the oral cavity. A cut point for elevation was more evident, however, with “range of liquids,” where patients with a tongue elevation greater than 1.5 cm had higher scores (6 of 6 for those with an elevation greater than 1.5 cm vs 5.25 of 6 for those with an elevation of ≤1.5 cm; P=.20). The mean flap area was 50 cm² (range, 24-80 cm²) and was not related to elevation or protrusion scores, indicating that the size of the flap chosen was appropriate to the size of the defect. Microneural repair of the lingual nerve to the flap was also not related to the functional measures. The 3 patients with associated base of tongue defects who had a complete hemiglossectomy did not differ in speech, swallowing, elevation, or protrusion measures suggesting that this approach adequately reconstructs the base of tongue.

There were 2 minor complications, one each of wound abscess and hematoma, no major complications, no flap salvages, and no flap losses. Of the 13 patients, 11 had a body mass index (calculated as weight in kilograms divided by height in meters squared) that was 22 or greater (normal range, 20.0-24.9) 1 year after the completion of treatment.

The rectangle tongue template is an effective approach for the reconstruction of the hemiglossectomy defect. Of the 13 patients, 12 achieved oral cavity obliteration, could protrude the tongue to their incisors, and could elevate the tongue at least 1 cm above their incisors. This level of function facilitated eating solids in 12 of 13 patients and speaking in public without restriction in 11 of 13 patients. The rectangle tongue reconstruction was associated with a minor complication rate of 2 in 13, with 1

**Figure 3.** Six administered questions that assess speech and swallowing function.

**Figure 4.**
patient developing a recurrence in the first 2 years of follow-up.

The rectangle tongue must be compared with several innovative reconstructive options published in the literature for hemiglossectomy defects. These include the bilobed design,5 the conical reconstruction,4 the longitudinal reconstruction,2 and the omega reconstruction.6 These reconstructive approaches were designed to obliterate the oral cavity and optimize tongue protrusion to maximize the oral phase of deglutition. The rectangle tongue was developed in an attempt to create a more dynamic reconstruction than the bilobed flap and a technically more straightforward reconstruction than the conical reconstruction. The longitudinal fold reconstruction developed at Washington University had not yet been published at the time rectangle tongue template was developed.3

Among 10 patients who underwent reconstruction with the sensate bilobed tongue design, 4 obtained a full diet, 1 became G-tube dependent, 10 could carry on a telephone conversation, and 8 developed 2-point discrimination of 15 mm or less.3 The results with the rectangle tongue reconstruction are good enough to warrant formal comparison. One of the advantages of the rectangle tongue reconstruction may be the ability of the fold, along the line of tension, to roll in and out with protrusion of the tongue.2 The rolling fold facilitates the tip of the tongue maintaining a midline sagittal position with protrusion and retraction.

The conical reconstruction published by Salibian et al4 is a sophisticated reconstruction that independently reconstructs the oral tongue and the floor of mouth. Among 13 patients, this approach resulted in 9 patients obtaining a selected normal diet, 3 patients obtaining a puréed diet, and 1 patient becoming G-tube dependent. Eight of 12 patients had speech that was understandable to an uneducated listener. This cohort had 6 patients who underwent composite mandibulectomy and an iliac crest free tissue transfer, which represents a more complex reconstructive group. Although not quantitated, there were examples of tongue protrusion that achieved premaxillary contact with the mouth fully open. The results with the rectangle tongue reconstruction are similar but did not achieve this level of premaxillary contact and would also require formal comparison. A potential advantage of the rectangle tongue compared with the conical tongue is the more straightforward inset.

The results of the longitudinal fold reconstruction developed by Haughey et al5 could not be assessed because only 4 of 42 patients underwent a hemiglossectomy reconstruction and the results were not independently reported. Among 15 patients, the omega reconstruction resulted in 5 patients obtaining a full diet and 15 patients obtaining a soft diet. Seven of 13 patients had normal or near normal articulation. Again, the rectangle tongue reconstruction is associated with better scores for speech and swallowing, but comparison is not valid because there are differences between the defect groups and there are no consistent outcome measures.

To facilitate comparison of reconstructive approaches, we assessed oral cavity obliteration and pre-maxillary contact and developed an elevation-protrusion plot. The elevation-protrusion plot is a novel concept to assess the relationship of 3 variables: the vertical height of the reconstruction, the ability of the residual tongue to recapitulate the “finger function,” and the relation of these measures to assessments of speech or swallowing. Our results show that if a patient can protrude the tongue more than 0.8 cm, they are more likely to eat a solid diet in public without restriction. In addition, if patients had a tongue elevation greater than 1.5 cm, they were able to drink liquids without restriction. This approach to assessment of oral cavity function will re-

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**Figure 4.** Bubble plots to assess relationship among 3 variables: tongue elevation, tongue protrusion, and functional speech and swallowing measures. For each patient, a bubble is plotted on the x-axis/y-axis coordinate of protrusion and elevation. Larger bubbles mean better (higher) speech and swallowing scores. A, Range of liquids. Better scores were found with a tongue elevation greater than 1.5 cm. B, Range of solids. Better scores were found with a tongue protrusion greater than 0.8 cm (P=.045). C, Eating in public. Better scores were found with a tongue protrusion greater than 0.8 cm.
fine the objectives of new reconstructive approaches and facilitate their comparison.

A shortcoming of the rectangle tongue template technique is the contraction that occurs between the tip and the floor of mouth. The mean width of the flaps was 5.4 cm, and this contracted considerably, as evidenced by the mean protrusion of 0.7 cm and elevation of 1.7 cm from the incisors. To facilitate the “finger function” of the residual tongue, patients were given active exercises, with a minority undergoing passive exercises. It is our impression that an aggressive early regimen to resist contracture is critical to the success of this reconstruction. A second shortcoming is the inset. The steps need to be followed closely, particularly the line of tension, because it helps maintain tongue height and facilitate the “sliding” protrusion of the tongue.

The rectangle tongue consistently achieves the goals of oral cavity reconstruction. This was demonstrated objectively by the elevation-protrusion plot and the correlation of these measures with speech and swallowing function. Patients who can obliterate their oral cavity and can protrude their tongue greater than 0.8 cm have significantly better swallowing function.

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