REINNERVATED ANTEROLATERAL THIGH FLAP FOR TONGUE RECONSTRUCTION

Peirong Yu, MD

Department of Plastic Surgery, FC-8.2000, 1400 Holcombe Boulevard, Houston, TX 77030.
E-mail: peirongyu@mdanderson.org

Accepted 4 June 2004
Published online 30 September 2004 in Wiley InterScience (www.interscience.wiley.com). DOI: 10.1002/hed.20106

Abstract: Background. Total or near-total glossectomy defects are commonly reconstructed with rectus abdominis myocutaneous flaps for coverage. Sensory reinnervation has rarely been performed.

Methods. Thirteen consecutive total or near-total glossectomy reconstructions were performed in a 12-month period with anterolateral thigh flaps with \( n = 8 \) or without \( n = 5 \) sensory reinnervation to the lingual nerve. Two-point discrimination, Semmes-Weinstein monofilament testing, pain, and temperature testing were performed before and after 12 months of surgery. Speech and swallow functions were assessed with an established grading system.

Results. Innervated flaps had superior sensory recovery to noninnervated flaps in all testing modalities. Postoperative radiotherapy may delay sensory recovery. Swallow function was better in the innervated group. Return of sensation also improves overall patient satisfaction.

Conclusions. The reinnervated anterolateral thigh flap is a viable option to reconstruct total or near-total glossectomy defects with good speech and swallow functions. © 2004 Wiley Periodicals, Inc. Head Neck 26: 1038–1044, 2004

Keywords: tongue reconstruction; anterolateral thigh flap; sensory reinnervation; glossectomy; lateral femoral cutaneous nerve; lingual nerve; two-point discrimination; Semmes-Weinstein monofilament testing; pain sensation; temperature sensation; radiotherapy

Total or near-total glossectomy defects have typically been reconstructed with rectus abdominis myocutaneous flaps, which provide excellent coverage. Functional muscle transfer with motor reinnervation has been successfully attempted but with uncertain functional results because of the small number of cases and wide variations of speech and swallowing functions among glossectomy patients. Sensory reinnervation with the radial forearm flap for hemiglossectomy defects has been successful with return of near-normal sensation. There are few reports, however, in the literature describing the use of sensate flaps for larger defects. Matloub et al reported good sensory recovery and function with a sensate lateral arm flap for total or near-total glossectomy defects in four patients. Although no direct functional comparison has been made, the importance of intraoral sensation has been well documented. It seems that providing basic coverage for a glossectomy defect without sensory function is becoming less acceptable in modern practice. The thin radial forearm flap is insufficient to provide bulk for total or near-total...
glossectomy defects. The anterolateral thigh flap is a relatively thick flap and has been widely used in Asia for head and neck reconstruction. This flap is also gaining popularity in Western countries. The main advantages of this flap include simultaneous two-team approach, minimal donor site morbidity, and quick recovery, in addition to the ability to provide sensory reinnervation. In the past 2 years, the author performed more than 70 free anterolateral thigh flaps for head and neck reconstruction at The University of Texas M. D. Anderson Cancer Center, including 13 total or near-total glossectomy cases in this study. The purposes of this study were to investigate the degree of sensory recovery of the reinnervated anterolateral thigh flap and the clinical outcomes of total or near-total tongue reconstruction with this flap.

**PATIENTS AND METHODS**

Between August 2001 and July 2002, 24 patients received immediate free flap reconstruction by the author for glossectomy defects. There were 12 total or near-total (>90% of the total tongue) glossectomy defects reconstructed with free anterolateral thigh flaps (n = 9), rectus abdominis myocutaneous flaps (n = 2), or radial forearm flap (n = 1); six hemiglossectomy defects were reconstructed with anterolateral thigh flaps (n = 3), radial forearm flaps (n = 2), or lateral arm flaps (n = 1); and six combined glossectomy (total or near total) and mandibulectomy defects were reconstructed with an anterolateral thigh flap alone (n = 1), a rectus abdominis myocutaneous flap alone (n = 1), and a combination of a free fibular flap with an anterolateral thigh flap (n = 3) or with a radial forearm flap (n = 1). Of the 13 patients who underwent reconstruction with an anterolateral thigh flap for a total or near-total glossectomy defect in this study, seven were men and six were women. The patients’ mean age (± standard deviation) was 61 ± 10 years (range, 46–80 years). Patient data are summarized in Table 1.

**Surgical Techniques.** In patients with sensory reinnervation, the lateral femoral cutaneous nerve that innervates the anterolateral thigh flap skin was identified below the anterior superior iliac spine when the superior incision of the flap was made. The nerve consistently runs along the line connecting the anterior superior iliac spine and the superolateral patella in the deep subcutaneous tissue immediately above the fascia. The nerve was greater than 2 mm in diameter in most cases. An additional 5 cm of nerve was harvested by proximal subcutaneous dissection (Figure 1). The sensory nerve was sutured to the lingual nerve in each case with 8-0 nylon sutures.

For total glossectomy defects, which usually involve the entire floor of mouth contents including all the suprahyoid structures, the main body of the flap was anchored to the gingival mucosa anteriorly and pharyngeal mucosa posteriorly (inferiorly). The rest of the flap was deepithelialized and folded to reconstruct the floor of mouth (Figure 2). The end of the flap was suspended to the drill holes and periosteum of the mandible with 3-0 Prolene sutures. In addition, laryngeal suspension from the mandible was performed with circumhyoid sutures (0-Prolene) placed through the drill holes in the mentum on both sides of the midline as described by Weber et al.13 In obese patients, the flap was thinned as needed. The perforator patterns after it enters the fascia and subcutaneous layer were studied under loupemagnification as described previously.14 The main perforator usually gave off three or more branches that travel above the fascia, deep in the adipose layer, and straight to the subdermal plexus. After identifying the latter, the flap was thinned with direct excision, leaving 1 or 2 mm of fat on the dermis to protect the subdermal plexus and a cuff of tissue around the main perforator.

**Speech and Swallow Evaluation.** Speech and swallow functions were graded on the basis of

<table>
<thead>
<tr>
<th>Patient no.</th>
<th>Glossectomy</th>
<th>XRT</th>
<th>Sensate</th>
<th>Speech</th>
<th>Swallow</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Total</td>
<td>Post</td>
<td>Yes</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>Total</td>
<td>Post</td>
<td>Yes</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Near total</td>
<td>Prior</td>
<td>Yes</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>4</td>
<td>Near total</td>
<td>Prior</td>
<td>Yes</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>5</td>
<td>Near total</td>
<td>Post</td>
<td>Yes</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>6</td>
<td>Total</td>
<td>Post</td>
<td>Yes</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>Total</td>
<td>Prior</td>
<td>Yes</td>
<td>Lost to follow-up</td>
<td>Lost to follow-up</td>
</tr>
<tr>
<td>8</td>
<td>Near total</td>
<td>Post</td>
<td>Yes</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>9</td>
<td>Total</td>
<td>Post</td>
<td>No</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>Total</td>
<td>Prior</td>
<td>No</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>11</td>
<td>Near total</td>
<td>Prior</td>
<td>No</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>12</td>
<td>Total</td>
<td>Prior</td>
<td>No</td>
<td>N/A†</td>
<td>4</td>
</tr>
<tr>
<td>13</td>
<td>Near total</td>
<td>Post</td>
<td>No</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

Abbreviations: XRT, radiotherapy; Post, post-operative XRT; Prior, XRT received in the past.
* Patients 7 and 8 did not return for sensory testing.
† Patient 12 had total laryngectomy at the time of glossectomy.
criteria established in our institution. Their scores in the innervated and noninnervated groups were compared.

Speech intelligibility scale:
1. Gross errors, unintelligible speech
2. Multiple errors, intelligible speech if the subject is known to the listener
3. Multiple errors, intelligible speech if the subject is unknown to the listener
4. Minor errors, acceptable intelligible speech
5. No errors, normal intelligible speech

Deglutition scale:
1. Severe dysphagia, nonoral feeding only
2. Partial oral, partial nonoral feeding
3. Liquid diet only
4. Liquids and soft foods only, must wash soft foods back with liquid
5. Liquids and soft foods only, does not need to wash food back
6. Liquids, soft foods, and mechanical soft foods—beginning mastication
7. All food types except tough, fibrous meats
8. Normal deglutition, normal mastication, regular diet

Sensory Testing. Sensory testing was performed as described by others. The surfaces examined include the tip (distal 1 cm) and the dorsum of the neotongue. Sensory testing was also performed in the anterolateral thigh flap territory on the contralateral thigh. The following sensory assessments were performed 6 to 10 months after surgery and repeated 1 year after surgery: (1) Semmes-Weinstein monofilament testing; (2) static two-point discrimination with Dellon Disk Criminator; (3) hot (50°C) and cold (4°C) temperature perception by use of a small test tube filled with water at appropriate temperatures; (4) pain perception with a 27-gauge needle.

Statistics. The data are expressed as mean ± standard deviation. Unpaired and paired, two-
tailed Student’s t tests were used for statistical analysis.

RESULTS

Eight patients received sensory reinnervation of the neotongue, and five received noninnervated flaps. The mean ages for these two groups were not significantly different (62 ± 9 and 60 ± 14 years, respectively; p = .84). All flaps were transferred successfully. No postoperative pedicle thrombosis or flap failures occurred. Two patients had a small oral cutaneous fistula develop, which healed spontaneously within 3 weeks. Two patients died from myocardial infarction 8 and 12 months after surgery, respectively. All other patients are alive to date. A representative appearance of the neotongue 12 months after surgery is shown in Figure 3.

One patient was lost to follow-up 2 months after surgery, at which time she was not decannulated. One patient underwent a total laryngectomy at the time of glossectomy. Decannulation was achieved in all other 11 patients 5 to 330 days after surgery.

FIGURE 4. Speech and swallow functions in the innervated and noninnervated groups. Speech function was graded as 1 to 5 according to their intelligibility, and swallow function was graded as 1 to 8 on the basis of their diet status, as described in “Materials and Methods.” Swallow function was significantly better in the innervated group than in the noninnervated group. *p < .05.

FIGURE 5. Semmes-Weinstein monofilament testing performed 12 to 18 months after surgery showed significantly better sensation with the innervated flaps than noninnervated flaps in the tip and the dorsum of the neotongue. *p = .005.

FIGURE 6. Two-point discrimination testing results in patients reconstructed with innervated anterolateral thigh flaps with or without postoperative radiotherapy. Sensory testing was performed 6 to 10 months after reinnervation and repeated 12 to 18 months after reinnervation in the same patient.

FIGURE 7. Semmes-Weinstein monofilament testing in patients reconstructed with innervated anterolateral thigh flaps. Testing was performed 6 to 10 months after reinnervation and repeated 12 to 18 months after surgery. *p < .05 compared with the testing results obtained before 12 months after surgery.
after surgery (median, 15 days). No patients required subsequent laryngectomies.

Speech and swallow functions are summarized in Table 1 and Figure 4. Speech scores were $3.7 \pm 0.8$ and $3.3 \pm 0.5$ for the innervated and noninnervated groups, respectively ($p = .25$). Swallow scores were $5 \pm 2.5$ and $2.6 \pm 0.9$ for the innervated and noninnervated groups, respectively ($p < .05$). Two patients in the innervated group were tube-feeding dependent (one partially and one totally), and three patients in the noninnervated group were partially tube-feeding dependent.

Eleven patients with a follow-up of 12 months or longer were included for sensory testing, including six patients in the innervated group and five in the noninnervated group.

**Innervated Flaps Versus Noninnervated Flaps.**

*Two-Point Discrimination Test.* None of the five patients with noninnervated flaps could feel the discriminator. In the innervated group, five patients had a 2- to 4-mm (2.6 ± 0.9 mm) two-point discrimination, and one patient had 20-mm two-point discrimination after 12 months.

Two-point discrimination was also tested on the contralateral thigh in the territory of the anterolateral flap. It was greater than 15 mm in all patients.

*Semmes-Weinstein Monofilament Testing.* Testing results 12 months after surgery for the two groups are summarized in Figure 5. The innervated flaps had a significantly lower threshold than the noninnervated flaps ($p = .001$).

Threshold testing on the contralateral thigh in the anterolateral flap territory averaged $2.83 \pm 0.58$ and $2.97 \pm 0.38$ for the innervated and noninnervated groups, respectively ($p = .93$).

*Pain Sensation.* None of the patients in the noninnervated group had pain sensation, whereas all patients with innervated flaps had pain sensation in the tip and dorsum of the neotongue.

*Temperature Sensation.* Only one patient in the noninnervated group had hot sensation, whereas five of the six patients with innervated flaps had both hot and cold sensation.

*Effect of Postoperative Radiotherapy on Sensory Recovery.* Four of the six patients with innervated flaps received postoperative radiotherapy, and two did not. Sensory testing was performed 6 to 10 months after surgery and repeated 12 to 18 months after surgery in the same patient.

Two-point discrimination testing results are the same for the tip and the dorsum of the neotongue, and they are shown in Figure 6. Both patients without postoperative radiotherapy and one patient with postoperative radiotherapy achieved less than 3-mm two-point discrimination as early as 6 and 7 months after surgery. Two patients with postoperative radiotherapy had a greater than 15-mm two-point discrimination before 10 months of surgery, which decreased to less than 5 mm 16 months after surgery.

Semmes-Weinstein monofilament testing showed that there was a significant improvement of sensory recovery in the dorsum and the tip of the neotongue after 12 months of reinnervation compared with that before 12 months ($p < .001$). The tip of the neotongue achieved a lower...
threshold than the dorsum only before 12 months (Figure 7). Postoperative radiotherapy did not seem to affect the Semmes-Weinstein testing (Figure 8).

**DISCUSSION**

This study has demonstrated that the sensory recovery of the reinnervated anterolateral thigh flaps is much greater than that of the noninnervated flaps. Sensory recovery does not seem to be different in the tip and the dorsum of the reconstructed neotongue. Five of the six innervated flaps had a two-point discrimination between 2 and 4 mm (average, 2.6 mm) and a threshold testing between 2.83 and 4.56 (average, 3.7). One patient had 20-mm two-point discrimination and 5.88 threshold testing, probably because of technical failure of flap reinnervation, because no other causes can be determined. A review of the literature shows that average two-point discrimination ranges from 2 to 3 mm, and average threshold testing ranges from 2 to 3 log force.7,9 These results are similar to those of the reinnervated neotongues in this series. Similar results have been achieved with the reinnervated radial forearm flaps for hemitongue reconstruction.7,9 The radial forearm flaps are, however, much thinner than the anterolateral thigh flaps, which had an average thickness of 14 mm in the center of the flap. The anterolateral thigh flaps used in this series had a minimum dimension of 8 × 15 cm, significantly larger than the radial forearm flaps used for hemiglossectomy reconstruction. This study, therefore, demonstrates that reinnervation of such a large and thick flap is possible by coaptation of the lateral femoral cutaneous nerve to the lingual nerve.

It has been reported that once the radial forearm flap is transferred intraorally with the lateral antebrachial cutaneous nerve coapted to the lingual or alveolar nerve, sensation is superior to that in the native forearm skin.7,9 This is also true with the anterolateral thigh flap. Two-point discrimination in the anterior lateral thigh region is greater than 15 mm in all patients. Apparently this is due to the much larger cortical representation of the recipient nerve.7 These findings also suggest that the density of neurosensory receptors in the thigh skin is adequate for a much higher degree of sensory discrimination once transferred.

The results of this study also showed that there was a significant improvement of sensory recovery after 1 year. The testing results obtained between 12 and 18 months after surgery did not seem to show any differences between the irradiated and nonirradiated flaps. However, two-point discrimination results obtained between 6 and 10 months were superior in the nonirradiated flaps than the irradiated flaps despite similar flap thickness. Although the number of patients is too small for statistical analysis, these results seem to suggest that postoperative radiotherapy may have delayed sensory recovery. The effect of radiotherapy is less significant in threshold testing, pain, and temperature sensation. This is somewhat different from the innervated radial forearm flap, in which radiotherapy significantly affected the threshold, pain, and temperature sensation but not two-point discrimination.9 The reasons for this difference are unclear. It is, however, possible that different flap thickness and neurosensory receptors between these two types of flaps may respond to radiotherapy differently.

Spontaneous sensory recovery may occur without sensory nerve reinnervation, as shown in other studies.7,9,15 However, sensory recovery is usually not complete, and it depends on residual nerve population.16 Therefore, large noninnervated flaps for large defects may have worse sensory recovery than small and thin flaps. This may explain why the noninnervated anterolateral thigh flaps in this series had minimal spontaneous sensory recovery. Like the antebrachial cutaneous nerve of the radial forearm flap, the lateral femoral cutaneous nerve is a pure sensory nerve. This may be the reason that some patients in this series achieved near-complete return of sensation as shown with the radial forearm flaps.7,9 In contrast, the intercostal nerve of the rectus abdominis flaps is a mixed nerve composed of 70% motor and only 30% sensory fibers,17 resulting in inferior sensory recovery.18

It has not been demonstrated whether the return of sensation of the neotongue translates to better swallow and speech functions. Matloub et al10 showed good swallow and speech function after reconstruction of total and near-total glossectomy defects with reinnervated lateral arm flaps by use of videofluoroscopy and Fishner-Logemann test of articulation competence; however, no control groups that used noninnervated flaps were studied. It has been shown that regional zones of anesthesia of the oral cavity do impair chewing function in experimental conditions.12 In clinical patients, however, the extent of resection of the tongue and suprahyoid muscu-
lature, the bulk of the neotongue, and postoperative radiotherapy may also affect speech and swallowing function. These factors are comparable in the innervated and noninnervated groups of patients in this study. In addition, all of the cases were reconstructed by a single surgeon, minimizing the “surgeon variable.” Although speech intelligibility was not statistically different between these two groups of patients, swallowing function was significantly better in the innervated group than in the noninnervated groups. These results seem to suggest that sensory recovery in the neotongue improves swallowing function. In addition, a sensate neotongue provides a higher degree of patient satisfaction. All patients in this series expressed their pleasure of having a “numb, woody piece of meat in my mouth.”

The rectus abdominis myocutaneous flap has been commonly used to reconstruct total or near-total glossectomy defects. In the previous report of 14 patients from our department with the rectus abdominis myocutaneous flap, the mean speech intelligibility was 2.8 and the deglutition scale was 3.5. With the same grading system, the mean speech and swallowing scores in the innervated group of patients in this study were 3.7 and 5.0, respectively. It should be noted, however, that multiple surgeons were involved in the previous study. Muscle flaps experience significant atrophy over time, resulting in a decrease of bulk of the neotongue, especially after radiotherapy. Because of the thick subcutaneous tissue in the abdomen in the Western patients, the rectus abdominis myocutaneous flap may be too bulky to be placed intraorally in many patients. Some surgeons use the muscle only with skin grafting in these situations. These muscle flaps with skin grafts are, however, more prone to atrophy. The anterolateral thigh fasciocutaneous flap seems to have the right amount of bulk and maintain the volume better than a muscle or myocutaneous flap. This flap may have additional advantages in elderly patients, smokers with chronic obstructive pulmonary disease, and patients with other significant comorbidities because of the minimal donor site morbidity of this flap. Thus, the use of this flap may facilitate early mobilization and patient recovery, hence potentially minimizing postoperative morbidity and mortality.

In summary, adequate sensory recovery can be achieved with innervated anterolateral thigh flaps for total or near-total tongue reconstruction. Sensory reinnervation with this flap may improve swallowing function and overall patient satisfaction.

REFERENCES