

Reconstruction of the tongue with reinnervated rectus abdominis musculoperitoneal flaps after hemiglossectomy

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Abstract

Reconstruction of the tongue after glossectomy is a primary objective in the process of improving the life quality of patients suffering from tongue cancer. We developed a new method of surgical reconstruction of the tongue after hemiglossectomy, with reinnervated rectus abdominis musculoperitoneal flaps. The rectus abdominis musculoperitoneal flap consisted of the rectus muscle, posterior rectus sheath, peritoneum, the 10th, 11th and 12th intercostal nerves, and the deep inferior epigastric artery and veins. Five patients underwent immediate reconstruction of the tongue with rectus abdominis musculoperitoneal flaps after hemiglossectomy. The intercostal nerves were anastomosed to the descending branch of the hypoglossal nerve. All transplanted flaps survived. The peritoneum was replaced by squamous epithelium eight weeks after surgery. During the follow-up period, the contour and function of the reconstructed tongues was satisfactory. Our experience indicates that reconstruction of the tongue with rectus abdominis musculoperitoneal flaps after hemiglossectomy is a suitable, cosmetically acceptable method.

Key words: Rectus Abdominis; Peritoneum; Reconstructive Surgical Procedure; Tongue Neoplasms; Glossectomy

Introduction

Reconstruction of the tongue after glossectomy is a primary objective in the process of improving the life quality of patients suffering from tongue cancer. The anatomy and function of the tongue are so complex that restoring its functionality after extirpative procedures has proved very difficult. With the development of microsurgical procedures, various techniques aimed at grafting free vascularized tissue into the remnant of the tongue have been widely attempted. Even so, current reconstruction techniques that yield satisfactory results in the treatment of tongue cancer are far from effective.

In recent years, the rectus abdominis myocutaneous flap, consisting of the skin paddle, anterior rectus sheath and rectus muscle, has been considered to be one of the most suitable flaps for the functional reconstruction of the tongue after total or subtotal glossectomy.^{1–4} However, for patients who have undergone hemiglossectomy, the rectus abdominis myocutaneous flaps are excessively bulky, lack pliability and may have hair.

In our opinion, a better option for tongue reconstruction after hemiglossectomy was use of the multilayer rectus abdominis musculoperitoneal flap, recently introduced in reconstructive surgery

procedures as a modification of the rectus abdominis myocutaneous flap. The rectus abdominis musculoperitoneal flap consists of the rectus muscle, posterior rectus sheath, peritoneum and a vascular pedicle that includes the deep inferior epigastric artery and veins. The rectus abdominis musculoperitoneal flap has the distinct advantages of being thin, pliable and without subcutaneous fat, and of having the potential to generate mucosa. It can be assumed that a flap with peritoneum as the surface of the reconstructed tongue would have better tissue compliance than a myocutaneous flap, and the bulk of the transferred tissue would also be smaller.

Thus, in order to improve the functional outcomes of tongue reconstruction, we trialled the use of reinnervated rectus abdominis musculoperitoneal flaps, with the intercostal nerves conjoined to the descending branch of the hypoglossal nerve. From 2003 to 2004, five patients underwent this reconstructive procedure, with inspiring results.

Patients and methods

Patient data

From October 2003 to September 2004, five patients suffering from carcinoma of the tongue underwent

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TABLE I
PATIENT DATA (1)

Case	Sex	Age (years)	Tumour site	Tumour size (cm)	TNM staging	Tumour differentiation	Neck dissection	Tracheotomy
1	Male	48	Posterior 2/3rds of left lateral border	4.5 × 3	T ₃ N ₁ M ₀	High	Yes	Yes
2	Male	50	Middle 1/3rd of left lateral border	3.5 × 2.5	T ₂ N ₀ M ₀	High	Yes	Yes
3	Male	51	Middle 1/3rd of right lateral border	3 × 3	T ₂ N ₀ M ₀	Moderate	Yes	Yes
4	Male	53	Middle 1/3rd of left lateral border	3.5 × 3.5	T ₂ N ₁ M ₀	High	Yes	Yes
5	Female	54	Middle 1/3rd of right lateral border	4.0 × 2.5	T ₃ N ₁ M ₀	High	Yes	Yes

T = tumour; N = node; M = metastasis

hemiglossectomy and immediate microsurgical reconstruction with a rectus abdominis musculoperitoneal flap, in the department of oral and maxillofacial surgery, College of Stomatology, Sun Yat-sen University, Guangzhou, China. The patients comprised four men and one woman. The average patient age was 51.2 years and ranged from 48 to 54 years. The primary tumours were previously untreated highly or moderately differentiated squamous cell carcinoma. According to the Unione Italiana Circoli del Cinema (UICC) tumour–node–metastasis (TNM) staging system, tumours were classified as T₂ N₀ M₀ in two patients, T₂ N₁ M₀ in one patient and T₃ N₁ M₀ in two patients. A modified radical neck dissection or functional neck dissection was performed on the same side in all patients. The internal jugular vein was preserved in the operation. One patient (case one) underwent neck dissection on the opposite side because of metastasis of neck lymph nodes three months after the initial surgery. All patients had elective tracheotomy after reconstruction. Three patients with pathologically positive cervical lymph nodes underwent post-operative radiotherapy (Tables I and II).

The rectus abdominis musculoperitoneal flaps with their intercostal nerves were transplanted during the same operative procedure. The flaps ranged from 8 × 5 × 2 cm to 10 × 7 × 2.5 cm in size and were adjusted to the defect of the tongue (Table II).

Anatomy of rectus abdominis

The rectus abdominis arises from the pubic symphysis and the pubic crest. The muscle inserts on the fifth, sixth and seventh costal cartilages above the costal margin, interdigitating with the pectoralis major muscle.

The predominant vascularization of the rectus abdominis is the inferior epigastric artery and the superior epigastric artery. The diameter of the vessel is always larger than 2 mm. There are also anastomoses between the terminal branches of the lower six intercostal arteries, the ascending branch of the deep circumflex iliac artery, and the inferior and superior epigastric arteries. Cadaveric, anatomic and animal injection studies have confirmed the

vascularity of the peritoneum via the deep inferior epigastric artery.⁵

The rectus abdominis receives a segmental innervation from the terminal branches of the lower six intercostal nerves. The nerves pass through the transversus abdominis and the internal oblique muscles and penetrate the sheath of the rectus abdominis laterally. According to Duchateau *et al.*,⁶ the nerves run between the expansions of the transversus abdominis on the posterior fascia of the rectus and enter the deep face of the rectus about 3 cm from its lateral edge.

Rectus abdominis musculoperitoneal flap creation and tongue reconstruction

A skin incision was made in the axial line, about 3 cm lateral to the midline, and carried through the subcutaneous tissues to the ventral sheath of the rectus abdominis. After incision and reflection of the anterior sheath, the rectus abdominis was divided from the anterior sheath. The 10th, 11th and/or 12th intercostal nerves were carefully separated. The deep inferior epigastric vessels were identified between the muscle and the posterior sheath and were followed until the vessels penetrated the transverse abdominal fascia at their origin from the external iliac vessels. The rectus abdominis was then dissected on three sides (cranial, lateral and medial). The posterior sheath, the underlying fascia and the peritoneum were incorporated with the rectus muscle. A caudally based patch flap was thereby created, with the vascular pedicle including the inferior epigastric artery and vein. Primary closure of the peritoneum was achieved in all cases. The anterior sheath was closed to avoid the risk of an abdominis hernia (Figures 1 and 2).

Following the neck dissection, hemiglossectomy was performed. On the same side of the floor of mouth, the suprahyoid muscles were resected down to the hyoid bone. After harvesting, the flap was transplanted to the stump of the tongue and the floor of the mouth. The flap was attached to the posterior plane of the hyoid bone and the mandible. The posterior rectus sheaths were attached to the cut ends of the deglutition muscles to create the tendinous insertions between the hyoid bone and mandible.

TABLE II
PATIENT DATA (2)

Case	Defect size (cm)	Flap size (cm)	Donor vessels	Recipient vessels	Donor nerve(s)	Recipient nerve	Post-op RT
1	60% of tongue, floor of mouth & suprahyoid muscles	10 × 7 × 2.5	Inf epigastric a & v	Sup thyroid a Anterior facial v	10th & 11th intercostal n	Desc branch of hypoglossal n	Yes
2	40% of tongue, floor of mouth & suprahyoid muscles	8 × 5 × 2.0	Inf epigastric a & v	Sup thyroid a Common facial v	10th, 11th & 12th intercostal n	Desc branch of hypoglossal n	No
3	50% of tongue, floor of mouth & suprahyoid muscles	8 × 6 × 2.2	Inf epigastric a & v	Facial a Common facial v	11th intercostal n	Desc branch of hypoglossal n	No
4	50% of tongue, floor of mouth & suprahyoid muscles	9 × 6 × 2.3	Inf epigastric a & v	Sup thyroid a Common facial v	11th intercostal n	Desc branch of hypoglossal n	Yes
5	50% of tongue, floor of mouth & suprahyoid muscles	10 × 6 × 2.0	Inf epigastric a & v	Sup thyroid a Sup thyroid v	11th & 12th intercostal n	Desc branch of hypoglossal n	Yes

Post-op = post-operative; RT = radiotherapy; Inf = inferior; Sup = superior; Desc = descending; a = artery; v = vein; n = nerve

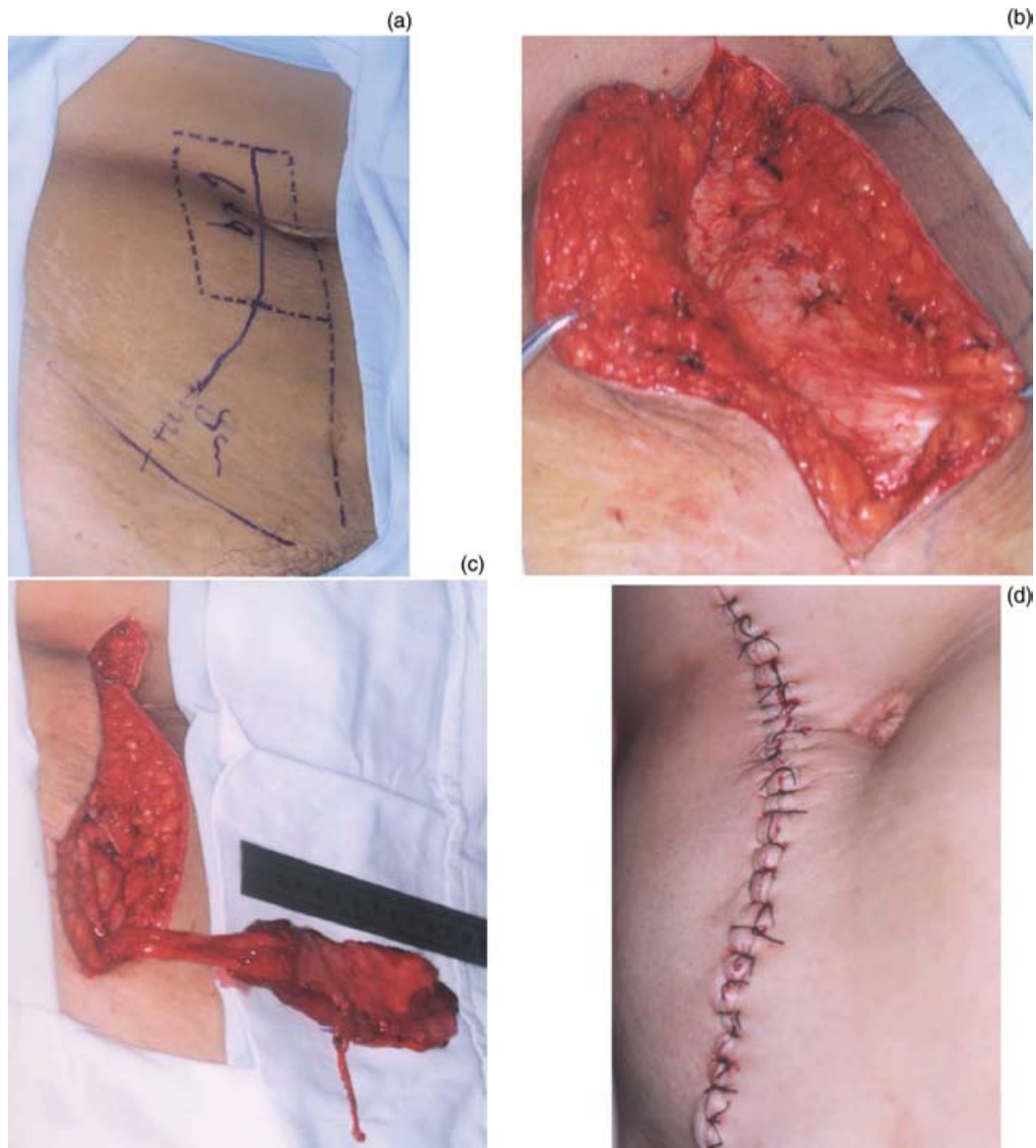


FIG. 1

Rectus abdominis musculoperitoneal flap creation. (a) The skin incision. (b) The anterior sheath of the rectus abdominis. (c) Creating the flap with its vascular pedicle (including the inferior epigastric artery and vein). (d) Primary closure of the incision.

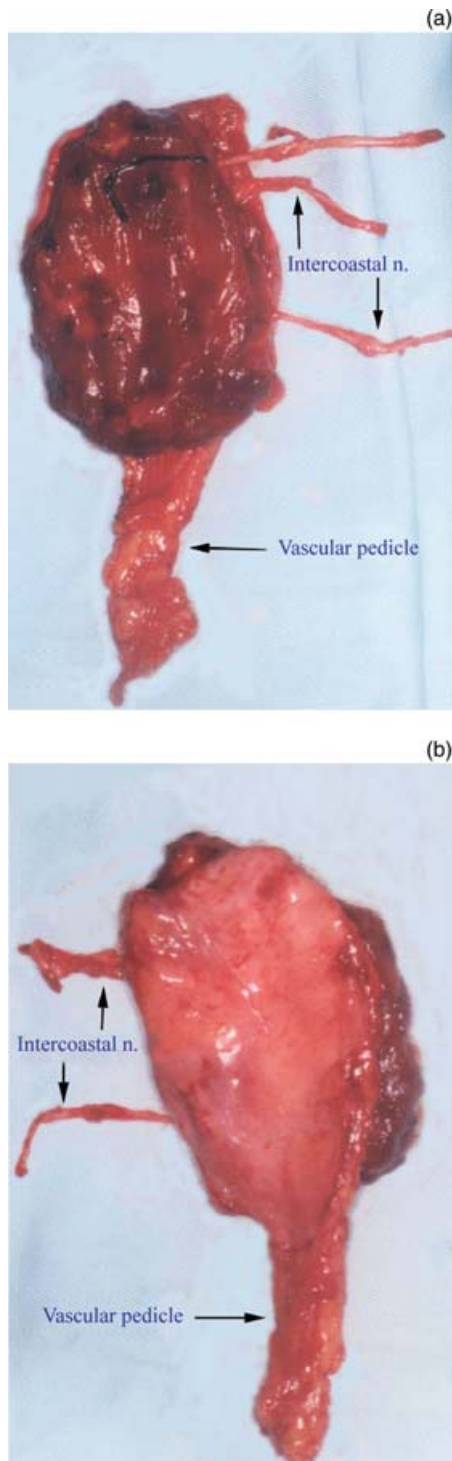


FIG. 2

The rectus abdominis musculoperitoneal flap consists of the rectus muscle, posterior rectus sheath and peritoneum, and the vascular pedicle (including the deep inferior epigastric artery and veins).

The remainder of the tongue was directly sutured to the muscular portion of the flap. The vascular pedicle was anastomosed to the recipient vessels (Table II). The proximal ends of the intercostal nerves were connected to the cut end of the descending branch of the hypoglossal nerve (Table II). The entire surgical

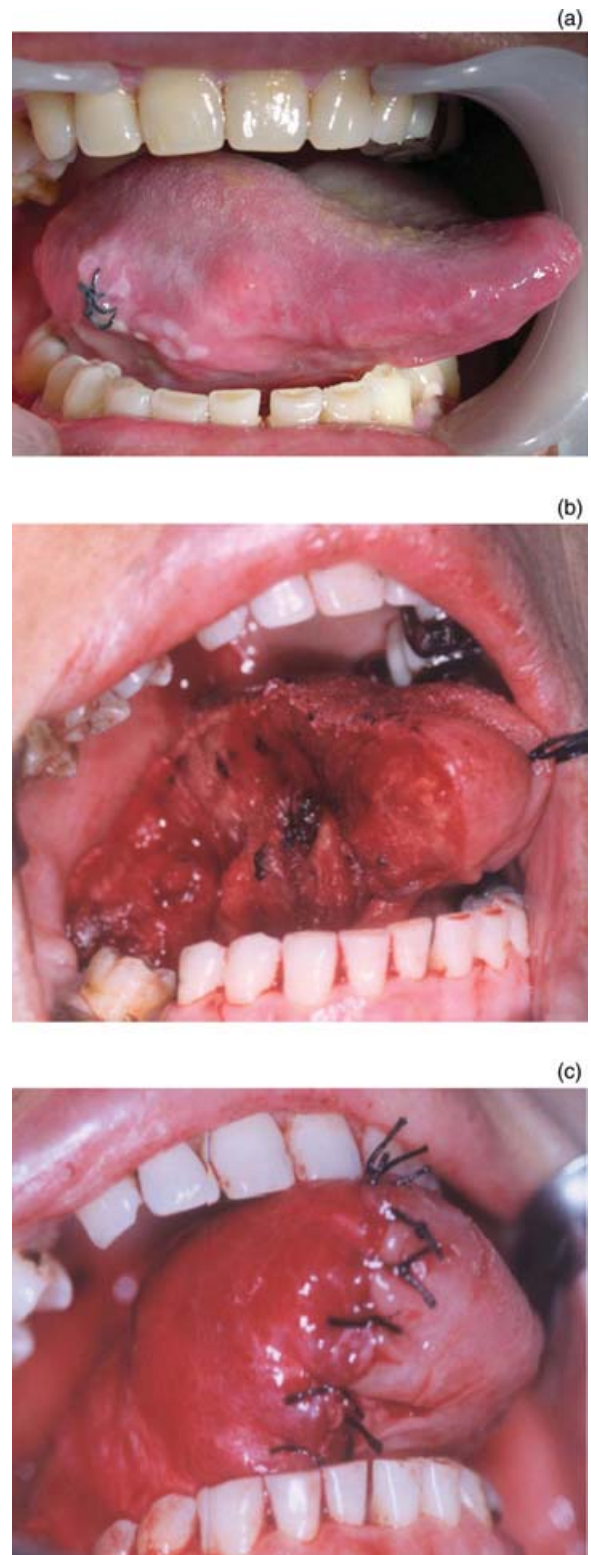


FIG. 3

Reconstruction of the tongue with the rectus abdominis musculoperitoneal flap. (a) Carcinoma of tongue in a 54-year-old woman (case 5). (b) Tongue defect after hemiglossectomy. (c) Immediate reconstruction of the tongue with the rectus abdominis musculoperitoneal flap.

procedure, including the resection and the reconstruction, took from seven to 10 hours (Figures 3 and 4).

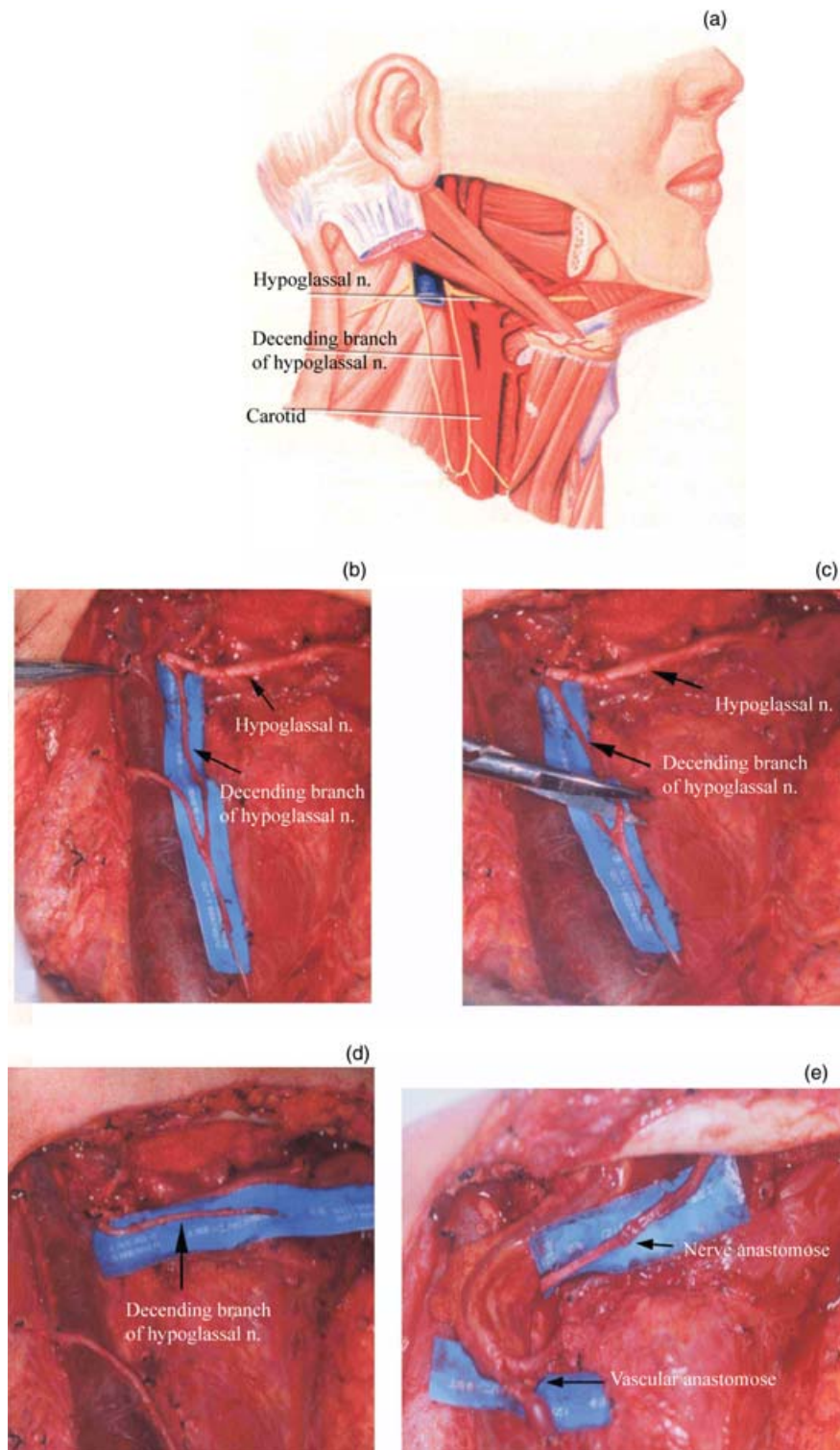


FIG. 4

Nerve anastomosis. (a) Descending branch of the hypoglossal nerve. (b) Relation of the hypoglossal nerve and the descending branch of hypoglossal nerve. (c) Descending branch of the hypoglossal nerve, divided during surgery. (d) Cut end of descending branch of the hypoglossal nerve. (e) Proximal ends of the intercostal nerves were anastomosed to the cut end of the descending branch of the hypoglossal nerve.

Post-operative functional analysis

The outcome of reconstruction was evaluated by follow-up examinations and questionnaires.

Three months after surgery, the University of Washington Quality of Life Questionnaire

(UW-QOL) was given to the patients to investigate the function of the reconstructed tongue. The speech function was evaluated by broad band phonography and linearity prognosticate chart for the Chinese Mandarin language.

Electromyography of the transferred muscle of case five was documented to evaluate muscular function nine months after surgery.

Results

All patients recovered uneventfully from surgery, with no immediate post-operative problems (i.e. no flap necrosis, wound infection, wound dehiscence or fistula).

All transplanted flaps survived. Two weeks post-operatively, the patients developed intelligible language, and one month post-operatively the patients were able to ingest a solid or semisolid diet.

The average follow-up period was 10 months, ranging from six to 15 months. There were no serious complications such as abdominal hernia or intestinal obstruction. All the patients survived without local recurrence.

During the follow-up period, the contour of the reconstructed tongues was satisfactory (Figure 5). Four reconstructed tongues provided appropriate bulk with some degree of atrophy. One of the reconstructed tongues provided insufficient bulk, and

showed obvious atrophy, although it had sufficient synchronized motion from the remaining tongue.

When followed up eight weeks after surgery, microscopic examination of a biopsy demonstrated that the flap was completely covered by squamous epithelium and that no peritoneal mesothelial cells could be identified (Figure 5).

The questionnaires given to the patients three months after surgery evaluated the swallowing, chewing, speech and taste functions of the reconstructed tongues (Table III). All patients were satisfied or reasonably satisfied with the outcome of their reconstruction.

The pre-operative and post-operative speech function was compared by broad band phonography and linearity prognosticate chart for the Chinese Mandarin language (Figure 6). The results showed that speech function was nearly normal three months post-operatively.

Spontaneous electromyography of the transplanted muscle of case five, performed while swallowing, was documented to evaluate muscular function nine months after surgery. The result showed that the muscle was functional (Figure 7).

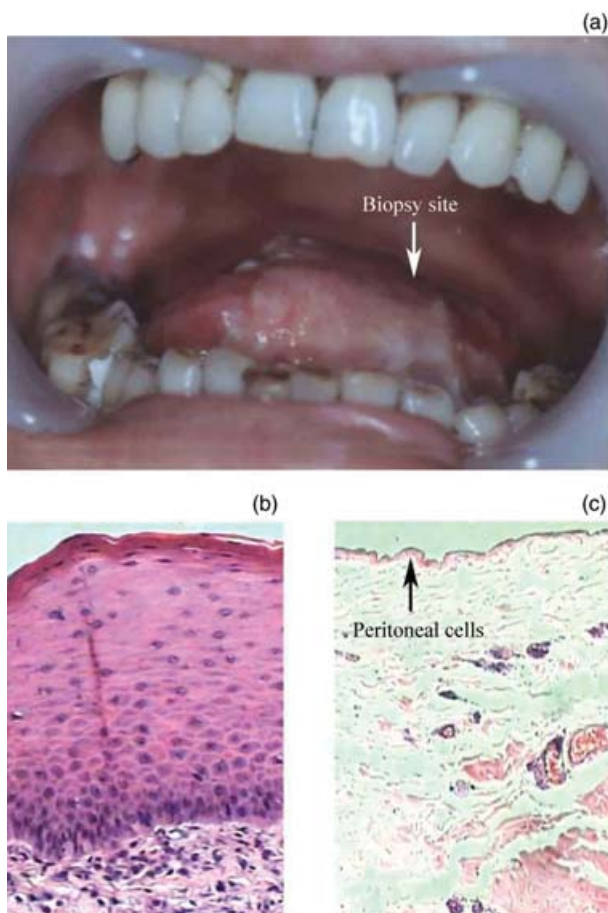


FIG. 5

Follow-up examinations three months after surgery. (a) Contour of the reconstructed tongue was satisfactory. (b) Complete coverage of the flap by squamous epithelium, with no identifiable peritoneal cells H & E, 200 \times . (c) Rectus abdominis musculoperitoneal flap before transplantation, for comparison H & E, 40 \times .

Discussion

Patients who undergo tongue resection often suffer clinically significant speech and swallowing deficits.⁷ Many previous studies have investigated possible ways to optimize function after tongue resection. Reconstruction after glossectomy, using a tissue graft of adequate bulk, can be successfully performed with microsurgical techniques. However, some patients have poor speech and swallowing function post-operatively. Many researchers have experimented with transfer of vascularized muscle flaps for dynamic recovery of the tongue; however, at the

TABLE III

PATIENT'S ANSWERS TO UNIVERSITY OF WASHINGTON QUALITY OF LIFE QUESTIONNAIRE

Question category	Answers	Patients (n)
Swallowing	I can swallow as well as ever	2
	I cannot swallow certain solid foods	3
	I can only swallow liquid foods	0
	I cannot swallow because it 'goes down the wrong way' and chokes me	0
Chewing	I can chew as well as ever	3
	I can eat soft solids but cannot chew some foods	2
	I cannot even chew soft solids	0
Speech	My speech is the same as always	2
	I have difficulty saying some words but can be understood over the phone	3
	Only my family and friends can understand me	0
Taste	I cannot be understood	0
	I can taste food normally	2
	I can taste most foods normally	3
	I can taste some foods	0
	I cannot taste any foods	0

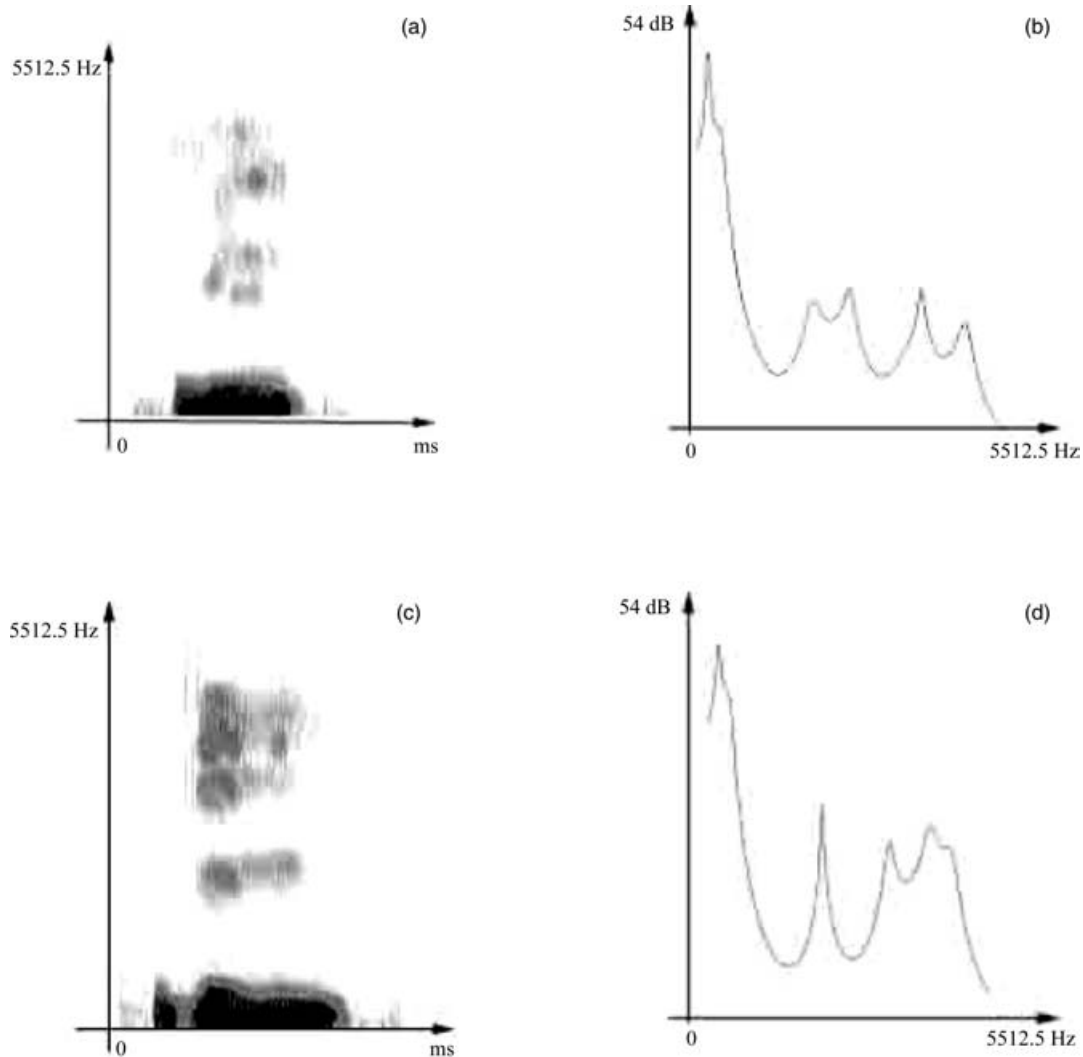


FIG. 6

Comparison of speech function before and three months after surgery. (a) Broad band phonogram of /i/ in Chinese Mandarin, before operation. (b) Linearity prognosticate chart of /i/ in Chinese Mandarin, before operation. (c) Broad band phonogram of /i/ in Chinese Mandarin, after operation. (d) Linearity prognosticate chart of /i/ in Chinese Mandarin, after operation.

time of writing, meaningful, coordinated dynamic movement has not been satisfactorily achieved.⁷

The reinnervation of transplanted muscle still remains a controversial issue. Katsantonis⁸ reported that the nonlingual muscle could be functionally

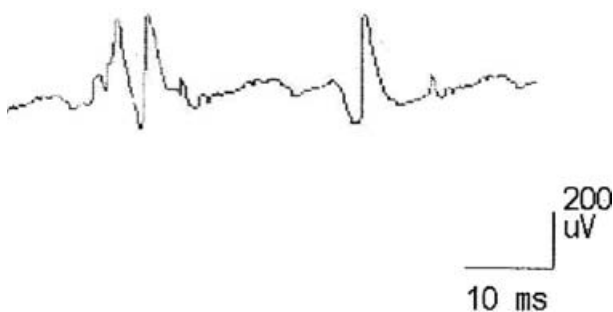


FIG. 7

Spontaneous electromyography of the transplanted muscle during swallowing, nine months after surgery (case 5).

reinnervated by either muscular (hypoglossal–genioglossus muscle pedicle) or neural (hypoglossal nerve pedicle) fibres, in an experimental study. Cheng *et al.*⁹ demonstrated the possibility of muscular-induced neurotization of the transplanted muscle flap by axons from the intact segment of tongue. In 1998, Yamamoto *et al.*² reported immediate tongue reconstruction using a reinnervated rectus abdominis myocutaneous flap in which the imbedded 10th intercostal nerve was connected to the remaining hypoglossal nerve. These authors strongly recommended this reconstructive technique for patients who had undergone subtotal glossectomy, to provide physiological functional recovery of the reconstructed tongue.

However, for patients who have undergone hemiglossectomy, the free rectus abdominis musculocutaneous flap is too large and bulky, with subcutaneous loose connective tissue, especially in overweight patients. Reconstructive surgeons have recognized that defects involving the tongue base require bulky

transplants in order to achieve satisfactory deglutition, whereas thin, pliable tissue (such as a radial forearm flap) is desirable for lesions involving the mobile, anterior part of the tongue.¹ Therefore, we considered that the rectus abdominis musculoperitoneal flap could provide pliable tissue of appropriate bulk and might yield better results for reconstruction of the tongue after hemiglossectomy. Post-operatively, we observed that the transferred muscle had sufficient synchronized motion with the remaining tongue, and that speech and swallowing function was satisfactory.

Recently, the rectus abdominis musculoperitoneal flap has been used in reconstructive surgery at various sites. Vaginal reconstruction with a rectus abdominis musculoperitoneal flap after extended radical pelvic surgery has been performed in many cases.^{10,11} Celayir *et al.*¹² successfully used a rectus abdominis muscle flap including peritoneum for the closure and augmentation of small, inelastic bladder extrophies, using a rabbit model with a large bladder defect. Based on their experience of eight grafts for large cheek defects, Riediger and Hettich¹³ considered it possible to simultaneously replace oral mucosa and soft tissue in deep, extensive cheek defects by transplantation of a multilayer myoperitoneal compound flap. Lanz¹⁴ reported that free tissue, vascularized transfer of the rectus abdominis myoperitoneal flap was successful in providing soft tissue reconstruction of the hard palate area in a dog. At the time of writing, there have been no reports on reconstruction of the tongue with a rectus abdominis musculoperitoneal flap.

The critical problem is whether the peritoneum can transfer to the oral mucosa. As we know, peritoneal cells are mesothelial cells, and the pluripotential capability of the peritoneum to support growth of differing cell types has been observed at other reconstructive sites. In 1993, Sadove *et al.*¹⁵ reported that rectus abdominis musculoperitoneal flaps could be used as urinary bladder wall substitutes in miniature swine. Histological photographs of the anastomosis between the peritoneum and bladder wall 20 weeks after surgery showed normal uroepithelium covering the entire surface of the bladder. Dadoukis *et al.*¹⁶ used pedicle grafts of peritoneum and transversus abdominis muscle for the duodenal wall. Four months post-operatively, histological photographs demonstrated that the patch was completely covered by newly formed mucosa that was similar to normal duodenal mucosa. In 2001, Nanni *et al.*¹⁷ proved the feasibility of urethroplasty using a free peritoneal graft in a rabbit model, and histological study showed that the inner surface of the graft was uniformly lined with normal uroepithelium. Niazi *et al.*¹⁰ reported that, in patients treated with vaginal reconstruction using rectus abdominis musculoperitoneal flaps, the peritoneal lining generated mucosa within two to three months. In our study, we observed that the peritoneum was replaced by squamous epithelium eight weeks after surgery. There is currently no evidence to confirm whether the epithelium was transferred from the peritoneal mesothelial cells or from adjacent oral mucosa,

although histological examination showed that the epithelium over the transplanted muscle was dissimilar to that on adjacent oral mucosa (Figure 5). Further studies are needed to identify the role of the peritoneum after transplantation.

During the follow-up period, we found that atrophy of the rectus abdominis musculoperitoneal flap was visually detectable. According to Kiyokawa *et al.*,¹ cutaneous flaps should be designed to be approximately 20 per cent larger than the defect in both breadth and length to ensure a reconstructed tongue of sufficient bulk. For our procedures we had indeed employed flaps that were approximately 20 per cent larger than the defect. Following our present experience, we now consider that this figure of 20 per cent is probably conservative and that a thicker and wider flap should be designed to ensure that reconstructed tongues are protuberant. Our experience was consistent with that of Kimata *et al.*,¹⁸ who considered that the width of the flap was more important than the length and who therefore suggested designing flaps approximately 30 per cent wider than the defect.

From our point of view, the advantages of reconstructing the tongue with a rectus abdominis musculoperitoneal flap are self-evident.

- (1) The flap is thinner than a rectus abdominis myocutaneous flap, especially in overweight patients.
- (2) The flap is pliable and easy to contour.
- (3) It never grows hair.
- (4) The flap has constant vascular anatomy, and the wide calibre of vessel makes it easy to anastomose.
- (5) The donor site can be sutured in place; preservation of the anterior rectus sheath and the oblique muscles can prevent post-operative hernia.
- (6) The peritoneum is quickly replaced by squamous epithelium.
- (7) Muscular neurotization of the transplanted muscle flap is possible.
- (8) Preparation of the flap is relatively simple to perform; surgeons have the advantage of performing the procedure simultaneously with the head and neck procedure.
- (9) The supply area is concealed and cosmetically acceptable.

It should be noted that we did not use a rectus abdominis musculoperitoneal flap for reconstruction after total glossectomy because we feared that the peritoneal tissue would be too tense to be successfully sutured in place.

Conclusion

Nowadays, several types of pedicled or free neurovascular muscle flaps have been trialled for functional recovery of the tongue in the treatment of tongue cancer. Surgeons have used the pectoralis major, sternocleidomastoid, infrahyoid, latissimus dorsi, medial pterygoid, rectus abdominis, tensor fasciae latae, gracilis and rectus femoris muscles, attempting to find a dynamic source for reinnervated tongue reconstruction.² This variety reflects the different clinical situations faced by reconstructive surgeons, and the dilemma surgeons face in deciding which technique is the most suitable for dynamic

recovery of the tongue. Further studies on the function of the tongue after reconstruction are required.

From our present experience, following hemiglossectomy we recommend reconstruction of the tongue and deglutition muscles of the floor of the mouth with a reinnervated rectus abdominis musculoperitoneal flap; we have found this to be a safe, suitable, cosmetically acceptable surgical technique. Long term follow up and further studies are needed to establish more final conclusions.

- **This paper describes a new method of surgical reconstruction of the tongue after hemiglossectomy, with reinnervated rectus abdominis musculoperitoneal flaps**
- **The rectus abdominis musculoperitoneal flap consists of the rectus muscle, posterior rectus sheath, peritoneum and a vascular pedicle that includes the deep inferior epigastric artery and veins**
- **The authors' experience with five patients is presented and they discuss the technique and advantages of this method of tongue reconstruction**

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