Third, with the aid of a neurosurgical team, the intratemporal facial nerve was mobilized from the mastoid cavity and used for the hypoglossal-facial nerve crossover. Direct neural communication without a nerve graft makes it possible to decrease the number of anastomoses without tension. More effective and earlier neural regeneration is expected by this technique (see Table 1).

Although this is a preliminary report describing the combined technique of nerve crossover and cross-nerve grafting, facial nerve rehabilitation based on double innervation, which consists of early and reliable reinnervation by the hypoglossal motor source and coordinated recovery by the contralateral facial motor donor, is a novel concept in the treatment of facial palsy. Further technical innovations via the cooperation of teams from the fields of plastic surgery, neurosurgery, and otolaryngology will be essential for further advances in facial reanimation surgery.

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Simple Maxillary Reconstruction Using Free Tissue Transfer and Prostheses

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Prosthetic rehabilitation is essential for maintaining postoperative oral function after maxillary reconstruction. However, the maxillary prosthesis becomes unstable in some patients because of extensive palatomaxillary resection and drooping of the transferred flap. In such patients, maintaining sufficient oral function is difficult, especially if the patient is edentulous. To achieve prosthetic retention, the authors performed microvascular maxillary reconstruction with a slit-shaped fenestration in the midline of the hard palate. Maxillary defects after subtotal or total maxillectomy were reconstructed with rectus abdominis musculocutaneous flaps in five patients. Defects of the nasal lining and palate were reconstructed with the single cutaneous portion of the flap, and a slit-shaped fenestration was left between the cutaneous portion of the flap and the edge of the remaining hard palate. Postoperatively, patients were fitted with maxillary prostheses that had a flat projection for the palatal fenestration. In all patients, the prosthesis was stable enough for mastication and prevented nasal regurgitation. Speech function was rated as excellent on Hirose's scoring system for Japanese speech ability. The authors believe that their method of palatomaxillary reconstruction is both simple and reliable. (*Plast. Reconstr. Surg.* 111: 594, 2003.)

Prosthetic rehabilitation is essential for maintaining postoperative oral function after maxillary reconstruction. However, maxillary prostheses may become unstable and cause oral dysfunction in some patients. Wide resection of the maxilla and surrounding tissues and drooping of the transferred flap also contribute to prosthetic instability. In edentulous patients, prosthetic stability and retention are particularly difficult to achieve. To resolve these problems in edentulous patients, we developed a simple method of maxillary reconstruction with a slit-shaped fenestration at the midline of the hard palate. The purpose of our method is to obtain competent palatal function with a maxillary prosthesis simply, effectively, and less invasively.

Patients and Methods

Subtotal or total maxillectomy was performed in five edentulous patients with advanced carcinoma (Table I). The orbital content was removed in two patients, and the facial skin was resected in one patient. Maxillary defects were immediately reconstructed with the methods described below. Of the five patients, two had received chemoradiotherapy and one had received radiotherapy. The mean total dose of radiation applied to the primary tumor site in these three patients was 47.3 Gy.

The surgical procedure, which comprised resection followed by immediate reconstruction, was performed with a two-team approach. After subtotal or total maxillectomy, a free rectus abdominis musculocutaneous flap was harvested according to the size of the resected area. The skin paddle was designed to meet the reconstructive needs of the palate and nasal lining (Fig. 1). Defects of the nasal lining and palate were reconstructed with a single cutaneous portion. The distal edge of the skin paddle was first sutured to the posterior superior margin of the medial nasal wall defect, after which the lateral border of the skin paddle was su-

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TABLE I
Patient Data*

Patient No.	Age/Sex	Diagnosis	Resection	Transferred Flap
1	76/M	Maxillary cancer (T4N0)	Total maxillectomy	RAMC + Rib
2	67/M	Maxillary cancer (T3N0)	Subtotal maxillectomy	RAMC
3	74/M	Facial skin cancer	Extended total maxillectomy	RAMC
4	73/F	Maxillary cancer (T4N0)	Extended total maxillectomy	RAMC
5	75/M	Cancer of nasal cavity (T4N2b)	Total maxillectomy	RAMC

* RAMC, rectus abdominis musculocutaneous flap.

tured to the posterior and anterior edges of the nasal defect. The skin paddle was bent at the margin of the palatal defect, and the palate was partially closed. A slit-shaped fenestration was left between the cutaneous portion of the flap and the remaining hard palate (Fig. 2). The vascular pedicle of the transferred flap was then microscopically anastomosed to the recipient vessels. After the flap was revascularized, the excess bulk of the flap was trimmed, and hemostasis was achieved. Next, the inferior border of the skin paddle was sutured to the buccal mucosa.

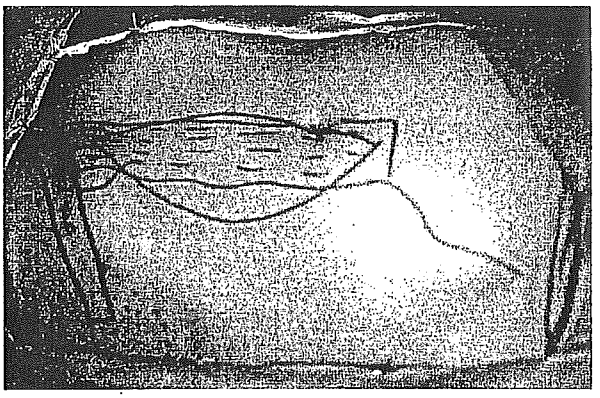

FIG. 1. Photograph showing the outline of a skin paddle of the rectus abdominis musculocutaneous flap designed to meet the patient's reconstructive needs.

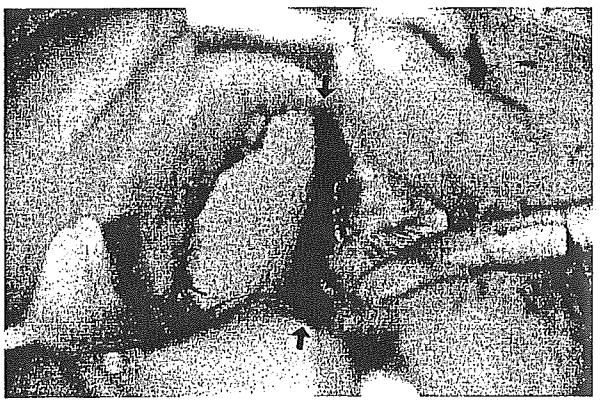

FIG. 2. Intraoperative photograph showing that the slit-shaped fenestration was left between the cutaneous portion of the transferred flap and the resected margin of the hard palate (*arrow*).

Palatal and maxillary dental rehabilitation was planned in consultation with doctors of the dentistry and oral surgery divisions. One month postoperatively, a maxillary prosthesis was made. The prosthesis has a flat projection that can be inserted into the palatal fenestration between the free margin of the hard palate, and the skin portion of the transferred flap provides stability (Fig. 3).

Postoperative palatal function with the maxillary prostheses was evaluated at least 6 months postoperatively. Masticatory function was rated "poor" if the patient could not change the consistency of food, "fair" if the patient had limited ability to do so, "good" if the patient could chew soft food, and "excellent" if the patient could chew regular food. Speech ability was evaluated on the basis of Hirose's 10-point scoring system (Table II). Nasal regurgitation was rated "poor" if there was continuous regurgitation of water, "moderate" if there was occasional regurgitation, and "excellent" if there was no regurgitation.

RESULTS

No operative complications were noted. Patients have worn their prostheses for 6 to 24 months. In all patients, the prosthesis was stable enough for mastication and satisfactory palatal function. Furthermore, masticatory function, speech function, and nasal regurgitation with the prosthesis were rated "excellent" in all patients. During the follow-up period, no signs of mucosal irritation, erosion, or any other problems around the edge of the defect were observed.

Patient 1 was a 76-year-old man with right maxillary sinus carcinoma underwent total maxillectomy through bitemporal incisions and an oral approach. Immediately after the tumor had been ablated, the defect was recon-

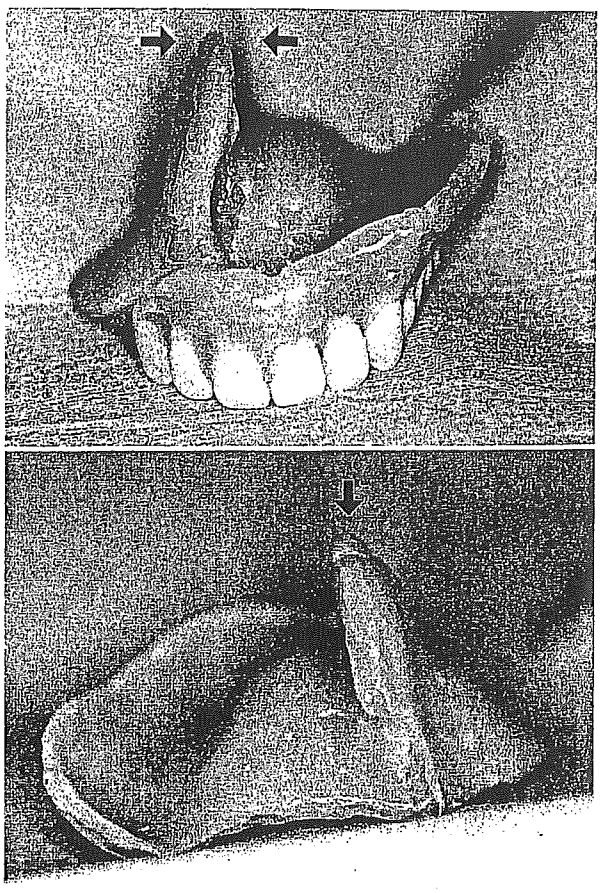

FIG. 3. The maxillary prosthesis was created 1 month postoperatively. The flat projection was made so that it could be inserted into the flat-shaped fenestration of the reconstructed palate (*arrows, above and below*). (*Above*) Anterior view. (*Below*) Posterior view.

TABLE II
Hirose's 10-point Scoring System for Japanese Speech Ability*

Factor	By Family	By Others
Clearly understood	5 points	5 points
Occasionally misunderstood	4 points	4 points
Understood only when subject is known	3 points	3 points
Occasionally understood	2 points	2 points
Never understood	1 point	1 point

* Hirose scoring system: 8 to 10 points, excellently intelligible speech; 5 to 7 points, moderately intelligible speech; 4 points or fewer, poorly intelligible speech.

structed with a rectus abdominis musculocutaneous flap and costal cartilage. As described above, a slit-shaped fenestration was left between the free margin of the hard palate and the skin paddle of the flap. One month postoperatively, a dental prosthesis was fitted. Oral function was evaluated 6 months later. The maxillary prosthesis was stable enough to allow mastication of a normal diet without nasal regurgitation. Speech function was excellent (Fig. 4).

DISCUSSION

Many methods have been described for closing palatomaxillary defects after tumor ablation including latissimus dorsi, rectus abdominis, and radial forearm free flaps with or without bony reconstruction.[1–4] Most authors think that a functionally competent palate is required for normal speech and mastication. Ideally, reconstruction of a functionally competent palate involves both bony and soft-tissue repair with separation of the oral and nasal cavities.[5]

Such three-dimensional reconstruction is complex, and many patients cannot tolerate lengthy operations, considerable donor-site morbidity, or invasive methods of reconstruction because of systemic complications or poor prognosis. In such patients, a simpler method of reconstruction is needed. The use of prosthetic devices alone is reliable, rapid, and noninvasive, but extensive maxillary defects may be difficult to close prosthetically. Furthermore, if a minimally invasive method of maxillary reconstruction is performed with free soft tissue only, sufficient retention and stability of the prosthesis can be difficult to achieve. Therefore, we developed a method of maxillary reconstruction in which a maxillary prosthesis is stabilized with a slit-shaped fenestration at the midline of the hard palate.

Our method has several advantages. Although osseointegrated implants with vascularized bone grafts may be the best method for obtaining complete support, retention, and stabilization of the denture, the surgical procedure is complex, and implants are relatively expensive. In contrast, our method is simpler, less invasive, and less expensive than the use of osseointegrated implants. As Funk et al.[4] reported in four patients in whom only soft tissue was used for partial palatal closure to decrease the bulk of the prosthesis, other advantages of our method are that the volume of the maxillary denture is decreased and the insertion of this prosthesis is easier.

A possible disadvantage of our method is leakage of air and liquid between the nose and mouth without a dental prosthesis. However, our patients had normal speech, swallowing, and nasal function and minimal leakage with a maxillary denture. Therefore, to prevent nasal

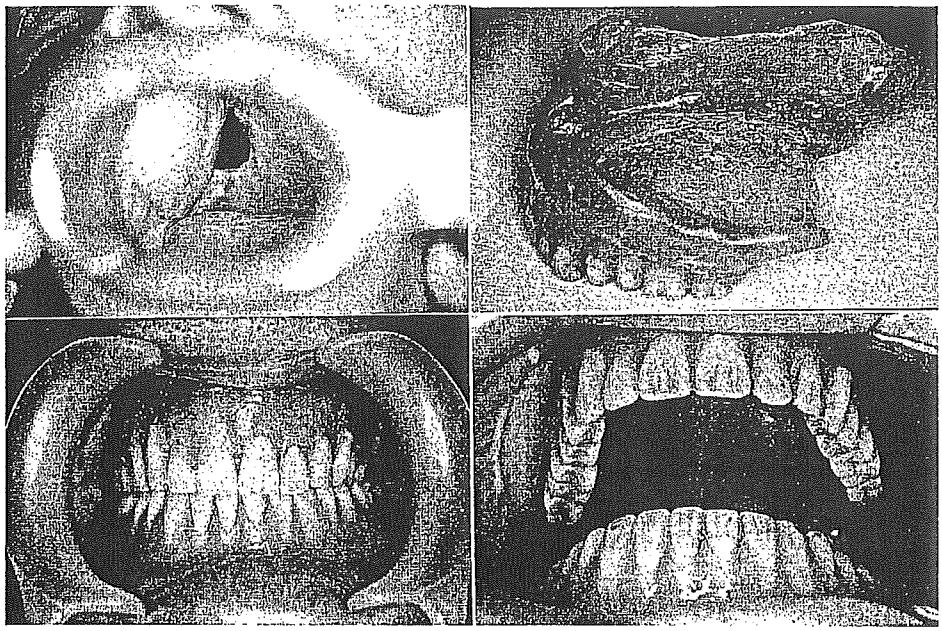

FIG. 4. Photographs showing the oral cavity of a 76-year-old man with maxillary carcinoma in whom reconstructive surgery was performed with a rectus abdominis musculocutaneous flap after total maxillectomy. (*Above, left*) Intraoral view at 6 months postoperatively. (*Above, right*) Lateral view of the maxillary prosthesis. (*Below, left and right*) The maxillary prosthesis was well stabilized during mastication.

regurgitation and to obtain prosthetic stability, the slit-shaped fenestration must be made as narrow as possible. At the time of reconstruction, the reconstructed palate must be in contact with the margin of the contralateral hard palate. A well-fitting maxillary prosthesis is essential with the use of our method, so palatal and maxillary dental rehabilitation must be planned in consultation with a maxillofacial prosthodontist. The prosthesis must later be revised or remade as the size of the slit-shaped fenestration changes along with the volume of the transferred flap. In our patients, the size of the defect became stable approximately 1 year postoperatively.

The number of remaining maxillary teeth

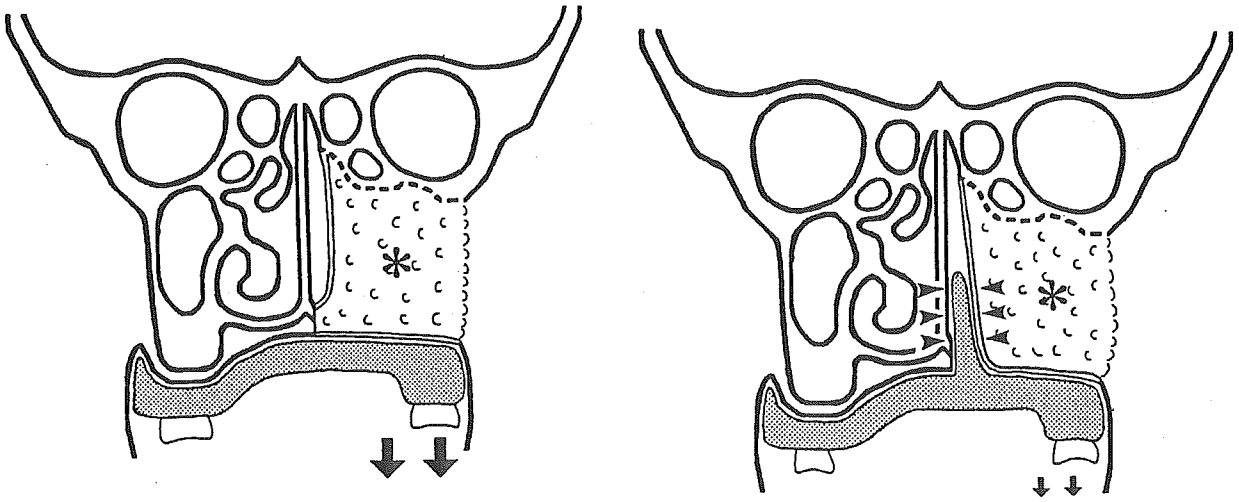

FIG. 5. Drawings illustrating our method of simple maxillary reconstruction. (*Left*) The maxillary denture (*dotted line*) easily drops down (*arrows*) in edentulous patients when the palate is completely closed with the skin flap (*). (*Right*) The maxillary prosthesis (*dotted line*) stabilizes with flat projection between a skin flap (*) and the margin of the hard palate (*arrowheads*). The downward force is reduced (*arrows*).

helps in making the determination whether a slit-shaped fenestration should be made. If the patient has enough maxillary dentition to retain and stabilize a dental prosthesis, we prefer to close the hard palate defect and separate the oral and nasal cavities. Funk et al.[6] also suggested that the palatal defects be closed completely in patients with enough teeth to maintain the dental prosthesis. In our edentulous patients, however, the maxillary denture was difficult to retain and stabilize when the hard palate was closed.

We think that a slit-shaped fenestration allows a well-fitted maxillary prosthesis with flat projection to be retained well and be stable enough for patients to achieve excellent speech, swallowing, and nasal function (Fig. 5). We think, however, that our method is most appropriate for patients whose maxillary dentition is not sufficient to stabilize a dental prosthesis.

CONCLUSIONS

Palatomaxillary reconstruction with a slit-shaped fenestration was performed to achieve stability of a maxillary prosthesis. Oral function after reconstruction was excellent. Our method is simple and effective in edentulous patients. We conclude that palatal reconstruction with a slit-shaped fenestration is useful for stabilizing a maxillary prosthesis.

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Analysis of the Relations Between the Shape of the Reconstructed Tongue and Postoperative Functions After Subtotal or Total Glossectomy

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Objectives/Hypothesis: **For reconstruction after subtotal or total glossectomy, both preserving the larynx and maintaining postoperative swallowing and speech functions can greatly improve quality of life; however, postoperative functional results are often unstable. Our experiences suggest that insufficient flap volume in the oral area and postoperative prolapse of the preserved larynx affect postoperative function. The objective was to investigate the relations of the shape of the reconstructed tongue to postoperative swallowing and speech functions.** ***Study Design:*** **The shape of the reconstructed tongue was classified on the basis of magnetic resonance and intraoral inspection as protuberant, semi-protuberant, flat, or depressed. Speech intelligibility was evaluated, and body weight, which might affect the shape of the transferred flap, was measured before and after surgery.** ***Methods:*** **Thirty patients who had undergone subtotal or total glossectomy and subsequent reconstruction were reviewed.** ***Results:*** **We found that speech intelligibility (P <.001), food (P <.01), and deglutition (P <.003) scores were significantly lower in patients with flat or depressed tongues than in patients with semi-protuberant or protuberant tongues. Weight loss after surgery was significantly greater in patients with depressed tongues than in other patients (P <.013). Our results indicate that postoperative function is related to the shape of the reconstructed tongue.** ***Conclusions:*** **We suggest that 1) wider and thicker flaps, such as rectus abdominis musculocutaneous flaps, be used; 2) flaps be designed to be approximately 30% wider than the defect; 3) laryngeal suspension be used to prevent prolapse of the transferred flap; and 4) careful general management and sufficient nutrition are important in the early postoperative period.** ***Key Words:*** **Reconstruction after subtotal or total glossectomy, shape of reconstructed tongue, postoperative functional analysis.**

Laryngoscope, **113:905–909, 2003**

INTRODUCTION

Reconstruction after glossectomy can be successfully performed with microsurgical techniques. We have achieved satisfactory results in reconstruction after subtotal and total glossectomy with laryngeal preservation in 95.3% and 70% of cases, respectively.[1,2] However, some patients have poor speech and swallowing functions after surgery despite laryngeal preservation. Predicting which patients will have satisfactory results and which will not is still difficult. Our experience suggests that factors likely to affect postoperative function include insufficient flap volume in the oral area, postoperative prolapse of the preserved larynx, advanced patient age, and poor motivation to swallow and speak. To resolve these problems and to obtain better functional results, we investigated the relations between the shape of the reconstructed tongue and postoperative swallowing and speech functions.

PATIENTS AND METHODS

Patient Data

We reviewed 30 patients (22 men and 8 women; mean age, 56.8 y; age range, 25–73 y) who had survived without local recurrence for at least 6 months after undergoing subtotal or total glossectomy for malignant tumors and immediate microsurgical reconstruction at the National Cancer Center Hospital East (Chiba, Japan) or the National Cancer Center Hospital Tokyo (Tokyo, Japan) from 1995 to 2000. We defined subtotal glossec-

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tomy as removal of more than two-thirds of the oral and pharyngeal portions of the tongue and defined total glossectomy as complete removal of the oral and pharyngeal portions of the tongue and the bilateral hypoglossal nerves. Patients had had malignant tumors of the tongue (28 patients), the tongue base (1 patient), or the anterior floor of the tongue (1 patient). Tumors were classified as T4 in 13 patients and as T3 in 10 patients and had recurred after initial ablative surgery, radiotherapy, or chemotherapy in 7 patients.

Subtotal glossectomy was performed in 23 patients, and total glossectomy was performed in 7 patients. Mandibulotomy because of tumor was performed in eight patients (segmental resection in three patients and marginal resection in five patients). Modified or radical neck dissection was performed in all patients.

Three kinds of free flap were transferred primarily: rectus abdominis musculocutaneous flaps in 25 patients, anterolateral thigh flaps in 3 patients, and pectoralis major myocutaneous flaps in 2 female patients. Of the three patients who had undergone segmental mandibulotomy, two underwent reconstruction with a titanium mandibular reconstruction plate and one underwent reconstruction with vascularized scapular bone. Twenty-two patients received tracheostomy after reconstruction under general anesthesia, and eight patients received endotracheal intubation.

Classification of Shape of Reconstructed Tongue

We classified the shape of the reconstructed tongue into four types (Fig. 1) on the basis of intraoral inspection and magnetic resonance imaging (MRI) in the sagittal plane performed at least 6 months postoperatively. The types were as follows: 1) The reconstructed tongue was classified as "protuberant" if it was excessively bulky and prevented observation of the oropharynx: MRI showed that the reconstructed tongue came into contact with the superior wall of the oropharynx; 2) the reconstructed tongue was classified as "semi-protuberant" if it was dorsally convex but allowed observation of the soft palate: MRI showed that the tongue was not in contact with the superior wall of the oropharynx; 3) the reconstructed tongue was classified as "flat" if its dorsal surface was neither convex nor concave: MRI showed that the tongue had prolapsed toward the larynx; and 4) the reconstructed tongue was classified as "depressed" if it was dorsally concave. The epiglottis could sometimes be seen.

Postoperative Functional Analysis

At least 6 months after surgery, a questionnaire was given to the patients to investigate swallowing function. Questions about oral intake yielded a food score (range, 1–5 points), and questions about swallowing yielded a deglutition score (range, 5–15 points)[3] (Table I). Speech intelligibility was evaluated with Hirose's 10-point scoring system[4] (Table II). To determine whether the shape of the reconstructed tongue affected postoperative swallowing and speech functions, statistical analysis was performed.

Because changes in body weight after surgery might affect the volume of the transferred flap, we weighed the patients on the day before surgery and again on the day the shape of the reconstructed tongue was classified after surgery. Changes in body weight were compared between patients with different tongue shapes.

RESULTS

All transferred flaps survived except a rectus abdominis musculocutaneous flap in a 32-year-old woman who had undergone total glossectomy. In this patient, total necrosis of the flap occurred because of venous thrombosis

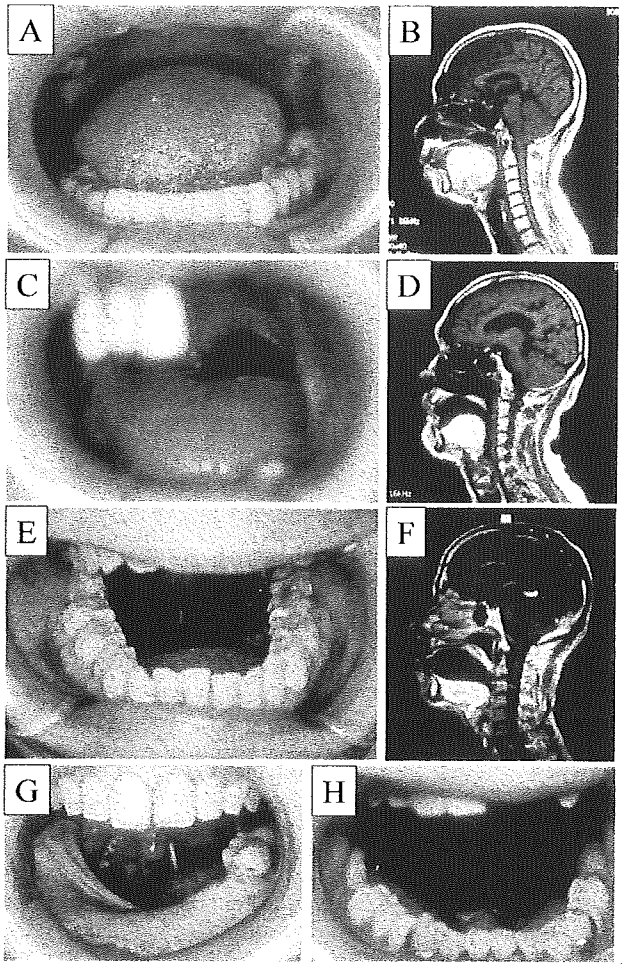

Fig. 1. Classification of the shape of reconstructed tongue. (**A** and **B**) Protuberant type. (**C** and **D**) Semi-protuberant type. (**E** and **F**) Flat type. (**G** and **H**) Depressed type.

5 days after surgery. A second operation was performed with an anterolateral thigh flap 6 days after the initial surgery. Minor orocutaneous fistulas developed in seven patients but healed with conservative treatment.

Decannulation was possible in 28 of the 30 patients in whom the larynx had been preserved. Two patients did not have decannulation because of intractable aspiration and pneumonia. Six months after surgery, these two patients were fitted with devices allowing speech through a tracheal stoma and were fed through a gastrostomy.

Postoperative Functional Analysis

The shape of the reconstructed tongue was classified and postoperative function was assessed at least 6 months postoperatively (mean period, 17.8 mo; range, 6–51 mo). Nine reconstructed tongues were classified as protuberant, 12 as semi-protuberant, 5 as flat, and 4 as depressed. Figures 2 and 3 show the relation between the shape of the tongue and postoperative swallowing and speech functions. Postoperative speech function was strongly and positively correlated with both the food score (correlation coefficient [r] = 0.80; $P < .000022$) (Fig. 2) and the deglutition score ($r = 0.76$; $P < .00005$) (Fig. 3). Speech intelli-

TABLE I.
Questionnaire and Records.

1) Food score (1 to 5 points)
- What kind of food do you take?

  Normal diet (5 points), minced (4 points), pureed (3 points),

  Fluid (2 points), tube feeding (1 point)

2) Deglutition score (5 to 15 points)
- Does a part of food remain in the mouth after swallowing?
- Do you swallow only a little amount of food at a time?
- Does a part of food go down into your throat before you begin to swallow?
- Does a part of food flow into the nose?
- Do you choke on food you are trying to swallow?

→	Never	(3 points)
	Sometimes	(2 points)
	Always	(1 point)

gibility scores (Mann-Whitney U test, $P < .001$), food scores ($P < .01$), and deglutition scores ($P < .003$) were significantly higher in patients in whom the reconstructed tongue was semi-protuberant or protuberant than in patients in whom the reconstructed tongue was flat or depressed.

Postoperative function was better after subtotal glossectomy than after total glossectomy, except in one patient, the 32-year-old woman described earlier who had undergone a second reconstruction operation with an anterolateral thigh flap after total glossectomy. Because the volume of the transferred flap was insufficient in this patient, the reconstructed tongue was flat. However, she could eat minced food and articulate well enough to converse naturally and talk over the phone almost normally.

Six of 30 patients gained weight after surgery, and 24 patients lost weight. Of the six patients who gained weight, five had semi-protuberant or protuberant tongues and one had a flat tongue (the 32-year-old woman described earlier). Weight loss after surgery was significantly greater in patients with depressed tongues than in other patients (one-factor ANOVA, $P < .013$) (Fig. 4).

TABLE II.
Hirose's Scoring System for Speech Ability.

Factor	A, by Family	B, by Others
1. Clearly understood	5 points	5 points
2. Occasionally misunderstood	4 points	4 points
3. Understood only when subject is known	3 points	3 points
4. Occasionally understood	2 points	2 points
5. Never understood	1 point	1 point

Scoring for A and B	Intelligibility
8 to 10 points	Excellently intelligible speech
5 to 7 points	Moderately intelligible speech
4 points fewer	Poorly intelligible speech

DISCUSSION

Because of the development of microsurgical procedures and the relatively low rate of early postoperative complications, attention today should be focused on ways to improve swallowing and speech functions after reconstruction following glossectomy. With current methods, a fully mobile tongue cannot be reconstructed. Therefore, preventing dysphagia and reacquiring articulation are important problems for patients. Few studies have examined the importance of the height of the reconstructed tongue for swallowing and articulation.[5–7] In 1992, Maegawa et al.[8] analyzed the relation of the shape of the tongue to articulation. However, more than half of their patients were treated with hemiglossectomy. In the present study, we found that in patients who had undergone subtotal or total glossectomy the shape of the reconstructed tongue was strongly correlated with postoperative swallowing and speech functions. This finding suggests that a transferred flap of sufficient bulk works with the buccal, palatal, and neighboring pharyngeal muscles to produce positive oropharyngeal propulsion pump forces. Also, speech intelligibility is increased when a reconstructed tongue has sufficient height and volume to come in contact with the hard palate.

An ideal method for determining how well the reconstructed tongue fills the oral space is to measure the volumes of the reconstructed tongue and the oral cavity with MRI. In our early cases, we tried to use MRI to measure the volumes of transferred tissues and observe their changes after surgery. However, we had difficulty distinguishing the transferred muscles and fatty tissue from the surrounding tissues. Therefore, in the present study, we simply classified the shape of the reconstructed tongue on the basis of its appearance on intraoral inspection and MRI.

Of our 30 patients, 9 had flat or depressed reconstructed tongues. In six of these patients, the volume of the transferred flap was insufficient. In these six patients, a rectus abdominis muscle (thickness, 5 mm) was transferred in two patients, an anterolateral thigh flap in two patients, and a pectoralis major myocutaneous flap in two patients because the subcutaneous fat of the pectoralis major myocutaneous flap was thicker than that of a rectus abdominis musculocutaneous flap. Furthermore, severe postoperative laryngeal prolapse occurred in two of these six patients. In two other patients with flat or depressed reconstructed tongues, mild cerebral dysfunction or excessive additional resection with glossectomy caused postoperative dysphagia, which reduced body weight and caused the transferred flap to atrophy. The cause of the flat reconstructed tongue in the remaining patient was not identified.

To help ensure that reconstructed tongues are protuberant or semi-protuberant, thicker and wider flaps must be used. Therefore, we prefer rectus abdominis musculocutaneous flaps, which can be elevated while the tumor is being resected with the patient in the supine position. Kiyokawa et al.[9] have suggested that to ensure a recon-

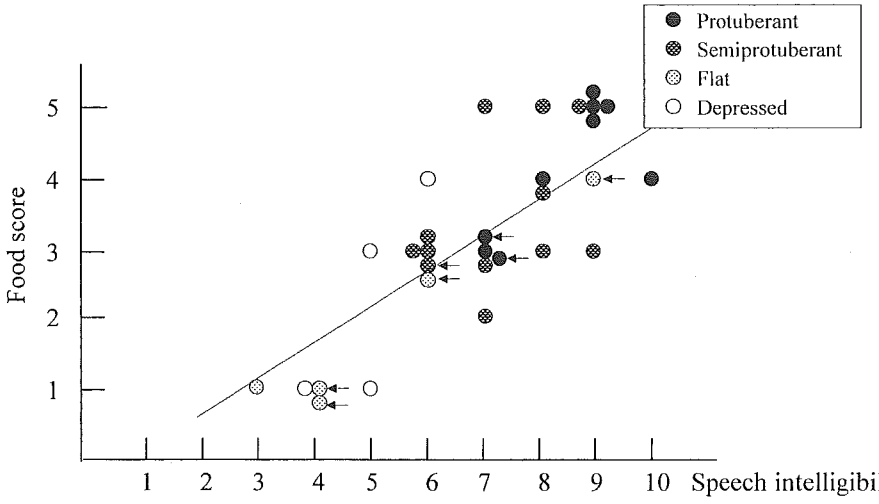

Fig. 2. Relation between tongue shape and postoperative speech and food functions. The horizontal axis indicates the speech intelligibility score, and the vertical axis indicates the food score (correlation coefficient [*r*] = 0.80). Arrows indicate patients undergoing total glossectomy.

structed tongue of sufficient height, cutaneous flaps should be designed to be approximately 20% larger than the defect in both breadth and length. Our experiences suggest that the width of the flap is most important, and today we intend to design flaps that are approximately 30% wider than the defect (9–10 cm in width in Asian patients). However, problems still arise in patients who have lost much weight. For such patients, several cutaneous flaps might be transferred to increase tissue volume.

We had thought that laryngeal suspension should be restricted, if possible, to restore physiological swallowing function and to avoid limiting the mobility of the neck. Cineradiographic studies[10] have shown that the presence of the hyoid bone and elevation of the larynx are not essential for effective swallowing. Indeed, most of our patients could swallow without additional laryngeal suspension. However, in two of our patients, severe laryngeal prolapse occurred and caused the reconstructed tongue to be depressed. Therefore, to prevent prolapse of the transferred flap, today we use thick nylon sutures to suspend the larynx from the mandibular bone (with approximately 2 cm between the superior border of the hyoid bone and the inferior border of the mandibular bone).

A decrease in body weight after surgery may be the result of early postoperative dysfunction and can lead to volume loss and malformation of the reconstructed tongue; conversely, existing malformation or insufficient volume of the reconstructed tongue may cause postoperative dysfunction, which then leads to a decrease in body weight. This suggests that, in addition to the reconstruction of a protuberant tongue, careful general management and sufficient nutrition in the early postoperative period are important.

Postoperative function of remnant tissues, which is difficult to evaluate preoperatively, is closely related to patient age. Although we could not demonstrate any significant relation between patient age and postoperative remnant-tissue function in our series, our experiences suggest that postoperative function is generally poorer in patients who are older than 70 years. In contrast, the functional compensatory ability of remnant tissues is significant in younger patients and allowed a 32-year-old woman in our series to achieve satisfactory postoperative function despite having a flat reconstructed tongue.

After we confirmed the relation of reconstructed tongue shape to postoperative functions, reconstructed

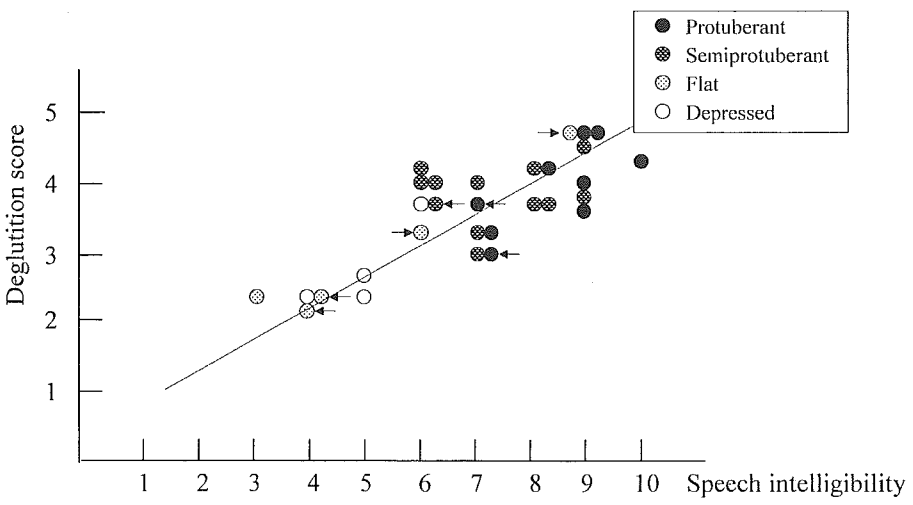

Fig. 3. Relation between the shape of the tongue and postoperative speech and deglutition functions. The horizontal axis indicates the speech intelligibility score, and the vertical axis indicates the deglutition score (correlation coefficient [*r*] = 0.76). Arrows indicate patients undergoing total glossectomy.

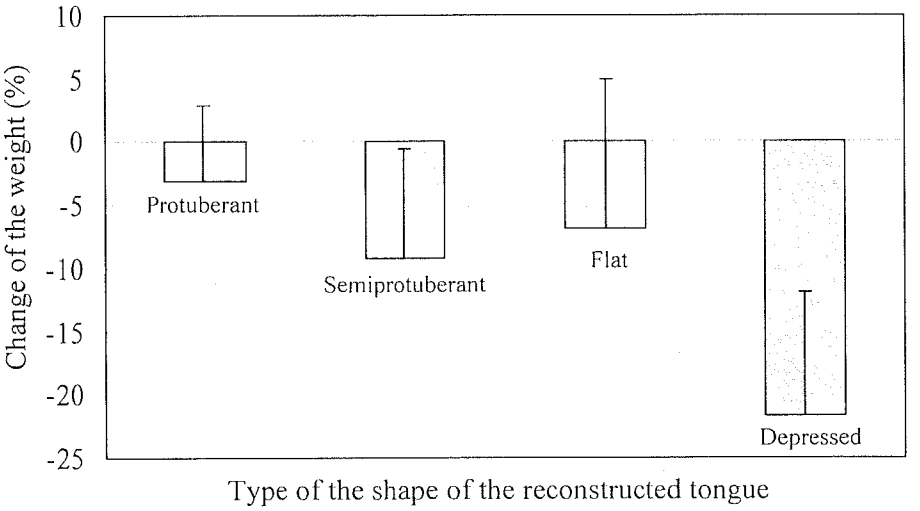

Fig. 4. Change in body weight among patients with the four types of reconstructed tongue. Weight loss after surgery was significantly greater in patients with depressed tongues than in other patients.

tongues in most of our recent cases have been protuberant or semi-protuberant. However, further reconstructive modification at this area will be necessary to improve swallowing and speech functions after reconstruction following glossectomy.

CONCLUSION

Our results indicate that postoperative function is related to the shape of the reconstructed tongue. Therefore, we suggest that wider and thicker flaps such as rectus abdominis musculocutaneous flaps should be used and that careful general management and sufficient nutrition are important in the early postoperative period.

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CLINICS IN PLASTIC SURGERY

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Deep circumflex iliac perforator flap

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The purpose of using the perforator flap is to minimize the donor site morbidity and to match the volume of the transferred tissues to the defect. Because of its width, length, and high vascularity, the vascularized iliac crest has become an important donor site in the reconstruction of the mandibular bone after ablative surgery. The iliac crest osteocutaneous free flap [1], however, has limited indications for intraoral reconstruction because the subcutaneous components, which includes a large amount of abdominal musculature, are bulky and immobile. To resolve these problems, Safak et al [2] investigated musculocutaneous perforators that are derived from the deep circumflex iliac artery (DCIA) and suggested that the volume of the iliac osteocutaneous flap can be reduced by not using a muscle cuff. Such a flap can be called a deep circumflex iliac perforator (DCIP) flap with iliac crest. This article describes its surgical anatomy, methods, a clinical case, and technical problems.

Surgical anatomy

The cutaneous perforators of the DCIP flap are usually derived from the DCIA, which is the predominant blood supply of the iliac bone. The DCIA arises from the external iliac artery and runs parallel to the inguinal ligament toward the anterior superior iliac spine. After giving off an ascending branch, which supplies the internal oblique muscle, the DCIA penetrates the transversalis fascia approximately 1 cm medial to the anterior superior iliac spine, and passes along the inner surface of the iliac crest. At about the midpoint of the crest, beyond the anterior superior iliac spine, the DCIA re-enters the transverse abdominis muscle and anastomoses with the iliolumbar arteries. In its course along the inner surface of the iliac crest, the DCIA gives off several small perforators, which penetrate the transverse abdominis, internal oblique, and external oblique muscles, and finally supplies the skin in an area extending 1 cm to 2 cm above the iliac crest and 5 cm posterior to the anterior superior iliac crest (Fig. 1) [2]. Taylor et al [3] reported that at least one dominant perforator (up to 1 mm in diameter) is always present. Safak et al [2] investigated anatomic variations in the branching pattern of perforators that are derived from the DCIA. In 70% of their dissections, the DCIA gave rise to a series of small perforators that penetrated the abdominal muscles to supply the overlying skin. In the remaining 30% of dissections, a dominant perforator and several smaller perforators were identified. In my experience, the DCIP flap can be elevated safely if dominant perforators (approximately 1 cm in diameter) are present [4].

Surgical methods

Before surgery, the presence and location of the dominant perforator of the DCIA are investigated with a Doppler flowmeter. The perforator is usually 1 cm to 2 cm above the iliac crest and 5 cm posterior to the anterior superior iliac crest. A skin flap is designed that includes the perforator and has a central long axis along the upper border of the anterior part of the iliac crest (Fig. 2). After a skin incision is made from the upper border of the skin flap, the flap is

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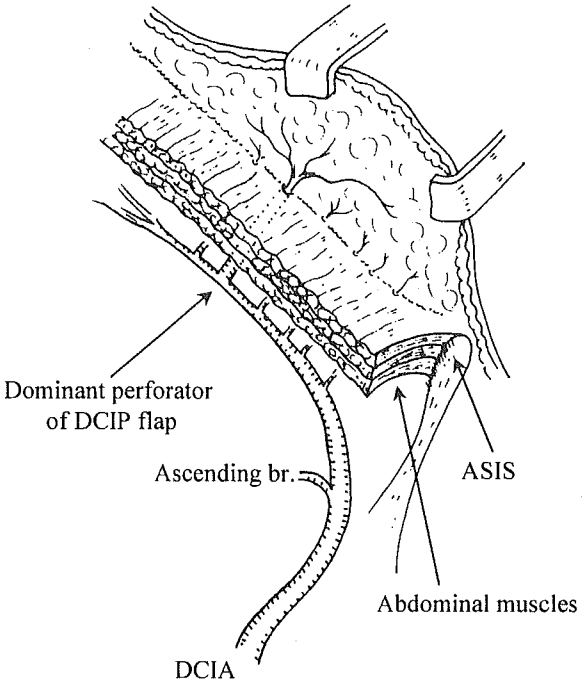

Fig. 1. Location of the deep circumflex iliac perforators. Abdominal muscles include transverse abdominis, internal oblique, and external oblique muscles. ASIS, anterior superior iliac spine; br., branch; DCIA, deep circumflex iliac artery.

elevated toward the iliac crest immediately above the external oblique muscle. During this procedure, the dominant perforator, approximately 1 mm in diameter, is identified as it emerges from the external oblique muscle. The dominant perforator is dissected free from abdominal muscles to the parent DCIA with careful ligation of the numerous small branches. Leaving a small cuff of abdominal muscle attached to the perforator helps protect it from damage. After the dominant perforator is isolated, the inferior border of the skin is incised and the DCIP flap is elevated from the iliac crest. The bone and DCIA are harvested in the usual manner (Fig. 3).

If the diameter of the dominant perforator is too small and complicates dissection from abdominal muscles during the previously described skin incision, the osteocutaneous flap should be elevated in the usual manner or a second free flap should be elevated as a cutaneous flap. If no perforators are identified on Doppler examination, other free flaps should be considered for intraoral reconstruction.

Clinical example

A 53-year-old man underwent composite resection with modified neck resection for cancer of the left mandibular gingiva. With two teams of surgeons, the mandibular bone and oral mucosa were immediately reconstructed with a DCIP flap attached to the iliac crest. A 4 cm × 10 cm DCIP flap with bone from the right iliac crest was designed and elevated. A dominant perforator, approximately 1 mm in diameter, was dissected with a small cuff of muscle. After the origin of the DCIA was isolated, a 3 cm × 6.5 cm segment of the iliac crest was harvested. The DCIP flap with iliac crest was transferred to the mandibular defect. The transferred cutaneous and osseous portions of the flap survived completely, and the postoperative course was uneventful. The patient was subsequently fitted with tissue-borne dentures (Figs. 4,5).

Advantages and technical problems

The DCIP flap with iliac crest offers several advantages over standard iliac crest osteocutaneous flaps for mandibular reconstruction. The DCIP flap has greater freedom from the harvested iliac bone on a single pedicle and is more pliable for easier contouring to complex defects of the oral cavity. Therefore, use of the DCIP flap facilitates the transplantation of bone and soft tissues to reconstruct mandibular and mucosal defects. The DCIP flap decreases the need for a secondary debulking procedure. Minimal sacrifice of the abdominal muscles also reduces donor site morbidity. Furthermore, the cosmetic defect might be

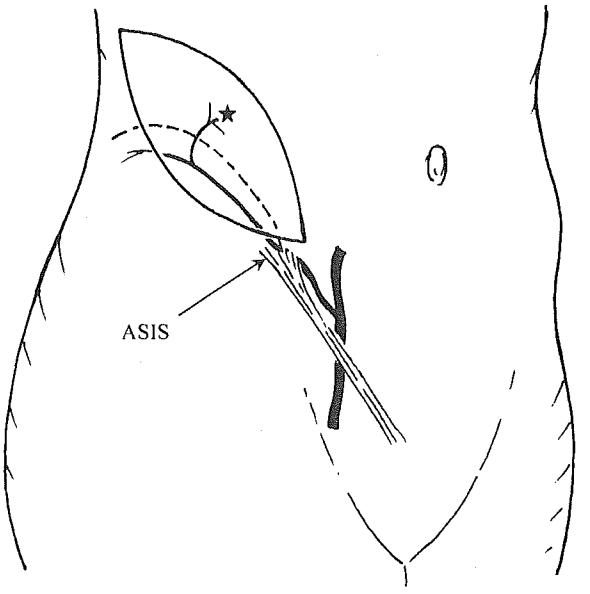

Fig. 2. Design of the DCIP flap with the right iliac crest. The dominant perforator is identified by Doppler flowmetry (*star*).

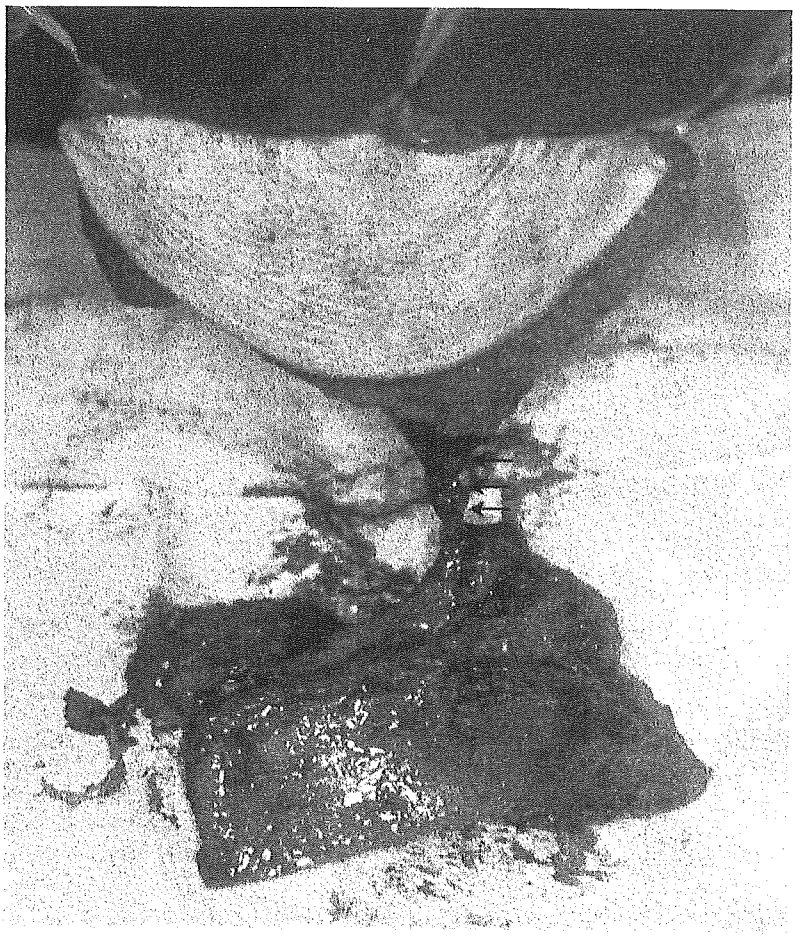

Fig. 3. The DCIP flap with iliac crest is elevated A small cuff of abdominal muscle is attached to the dominant perforator (*arrows*).

lessened if only the inner table of the iliac crest is elevated with the DCIP flap; however, we did not attempt to do so.

The DCIP flap can be elevated only if dominant perforators (approximately 1 cm in diameter) are present. At my institution, cutaneous perforators could be identified preoperatively with Doppler examination in 7 of 10 patients who underwent mandibular reconstruction with a DCIP flap with iliac crest. In five of these seven patients the dominant perforators were approximately 1 mm in diameter and a DCIP flap could be safely elevated and transferred to the intraoral defect. The transferred DCIP flap ranged from 4 cm to 8 cm in width and from 10 cm to 17 cm in length (Table 1).

In two of the seven patients, the dominant perforators were 0.5 mm in diameter and were extremely difficult to dissect from the abdominal musculature. Therefore, in one patient, a small amount of abdominal musculature was left attached to the dominant perforator when the flap was transferred with the iliac crest to the mandibular defect. In the other patient, only the vascularized iliac crest was harvested in the usual manner, and the intraoral defect was reconstructed with a free anterolateral thigh flap as a second flap.

In the three patients in whom perforators could not be identified preoperatively, several tiny branches that emerged from the external oblique muscle were identified from the upper incision of the iliac crest. The vascularized iliac crests were harvested in the usual manner for mandibular reconstruction and free groin flaps were transferred to reconstruct the intraoral defect.

Therefore, to ensure that the DCIP flap can be safely elevated, the presence of perforators must be confirmed preoperatively and intraoperatively. Even when a perforator has been identified, a complicated

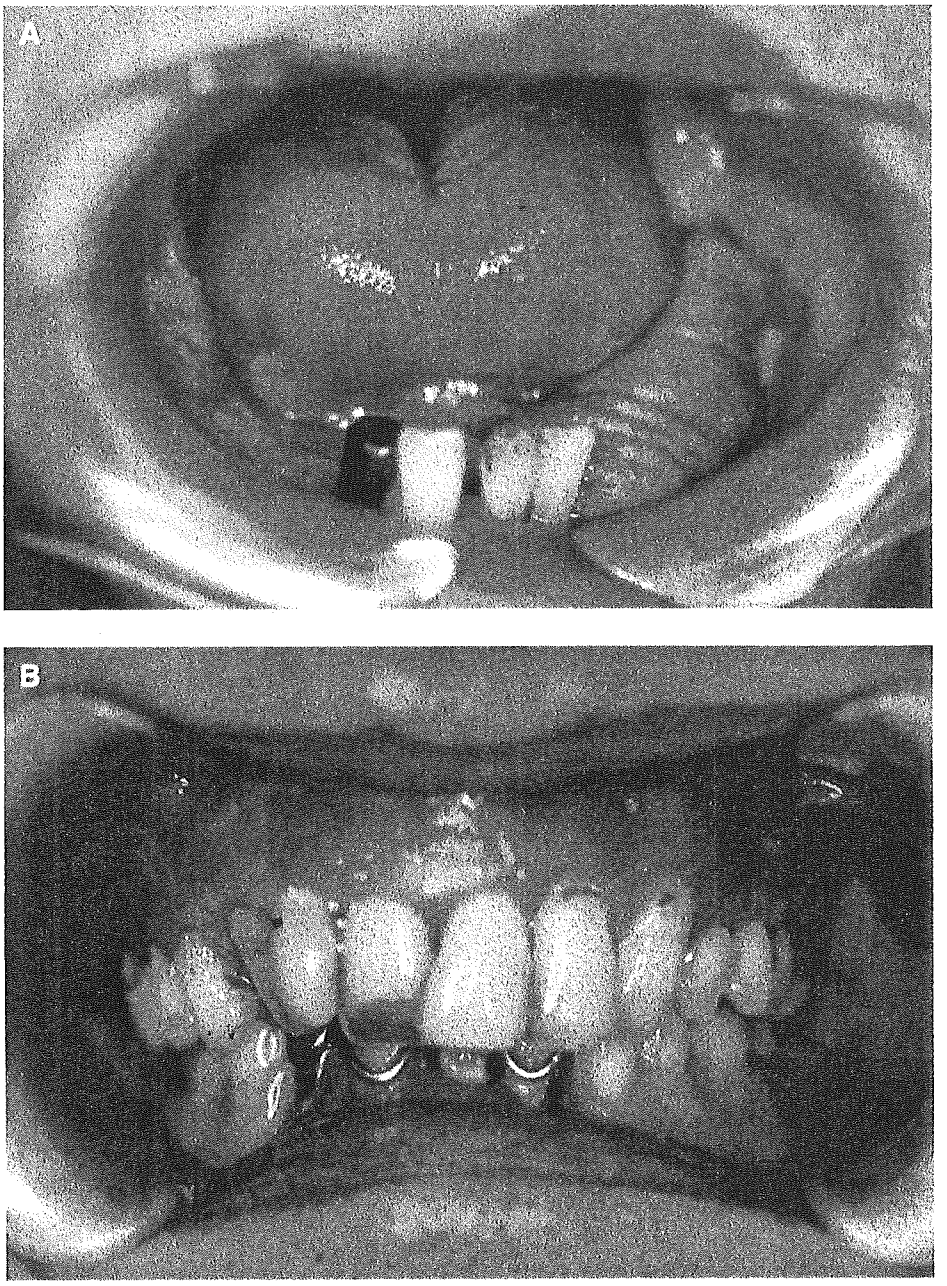

Fig. 4. (*A*) Intraoral appearance 36 months after reconstruction of the left mandibular bone. (*B*) Intraoral appearance with tissue-borne dentures.

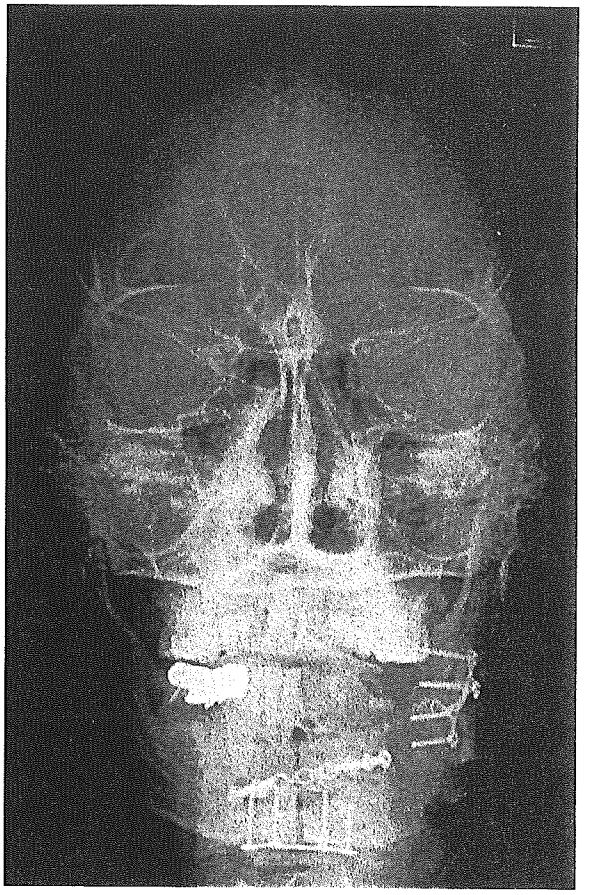

Fig. 5. Radiograph of the reconstructed mandible.

Table 1
Results of DCIP cases

Case	Sex (age)	Presence of perforator by Doppler examination	Diameter of dominant perforator	Transferred flap for intraoral defect	Flap size (cm)
1	M (53 yr)	Yes	1.0 mm	DCIP	4 × 10
2	M (67 yr)	Yes	1.0 mm	DCIP	8 × 15
3	F (67 yr)	Yes	1.0 mm	DCIP	6 × 12
4	F (59 yr)	Yes	1.0 mm	DCIP	6 × 10
5	M (20 yr)	Yes	1.0 mm	DCIP	7 × 17
6	M (56 yr)	Yes	0.5 mm	Osteocutaneous flap[a]	8 × 13
7	M (35 yr)	Yes	0.5 mm	Anterolateral thigh flap	6 × 12
8	M (67 yr)	No	None	Groin flap	6 × 10
9	F (73 yr)	No	None	Groin flap	7 × 7
10	M (66 yr)	No	None	Groin flap	8 × 15

[a] Cutaneous flap over the crest was transferred in the usual manner.

dissection may be necessary. Therefore, it is important to have a thorough knowledge of the anatomy of second flaps, such as radial forearm flaps, groin flaps, and anterolateral thigh flaps, and to obtain informed consent for them.

Summary

The increased freedom of the DCIP flap from the harvested iliac crest facilitates correct positioning. To ensure that the DCIP flap can be safely elevated, however, the presence of perforators (approximately 1 cm in diameter) must be confirmed preoperatively and intraoperatively.

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Free Perforator Flap for the Treatment of Defects After Resection of Huge Arteriovenous Malformations in the Head and Neck Regions

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The authors report two cases of huge arteriovenous malformations in the head and neck regions treated successfully with preoperative superselective transarterial embolization and resection followed by a free perforator flap transfer. Based on the authors' previous cases, en block mass resection of the malformation was possible with bleeding of less than 150 ml. The massive defects could be repaired with free perforator flaps using an anterolateral thigh flap and a deep inferior epigastric artery perforator flap. One patient who lost facial muscle underwent reconstruction by simultaneous muscle transfer, and both patients regained acceptable cosmetic appearance and dynamic facial function. Now, more than 4 to 7 years after surgery, the patients have shown no reexpansion of the malformation. The important points of this treatment are complete embolization to accomplish total resection with minimal bleeding, free flap transfer to prevent postoperative reexpansion or recurrence of arteriovenous malformations, and the selection of recipient vessels because of arterial embolization in part of the lesion.

Koshima I, Nanba Y, Tsutsui T, Takahashi Y, Watanabe A, Ishii R. Free perforator flap for the treatment of defects after resection of huge arteriovenous malformations in the head and neck regions. *Ann Plast Surg.* 2003;51:194–199.

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The treatment of huge arteriovenous malformations (AVM) in the head and neck regions is a difficult challenge for surgeons, because AVMs cause tremendous cosmetic, functional, and psychological problems. In addition, these lesions can be life-threatening.[1] Sometimes patients can die of uncontrollable bleeding with or without surgery. The problems confronted by surgeons include incomplete resection resulting in massive bleeding, postoperative enlargement of the remaining malformation, and a poor cosmetic appearance.

Halstead in 1919[2] was one of the first authors to describe the difficulty in management of congenital AVMs and the high recurrence rate associated with these lesions. In 1930, Brooks[3] first used embolization to treat vascular malformations. He embolized autogenous muscle to treat a carotid cavernous fistula. Thereafter, in 1965, Djindjian et al[4] introduced superselective angiography.

Recent advances in vascular intervention using superselective vascular embolization and free-flap transfers established a new solution for this difficult treatment. Although there have been reports regarding the treatment of AVMs with pedicled or free flaps, reports with long-term follow-up have been rare. In this article, we describe two patients with successful treatment for huge AVMs who were followed-up for from 4 to 7 years after surgery. These patients had a long history of high-flow vascular malformation in the head and neck regions and underwent free perforator flap transfer after preoperative embolization and total or subtotal resection of the lesion.

Patient Reports

Patient 1

A 64-year-old man sought treatment for an extensive AVM involving the left cervical and temporal regions. Thirty years previously, he had

experienced easily repeated bleeding and resection of the ear involving the malformation, which was covered with skin graft. Twenty years ago, enlargement of the malformation and gross bleeding followed by shock sometimes occurred. One year previously, the patient could no longer tolerate left temporal pain and was transferred to our hospital.

Before the surgery, preoperative superselective transarterial embolization of the left external carotid system, including the left vertebral artery and transverse cervical artery, was performed using titanium coils and polyvinyl alcohol particles. The angiograms after embolization showed little flow to the lesion from the respective feeder vessels and the occurrence of multiple superficial necroses on the malformation.

Six weeks after the embolization, the patient underwent extensive resection of the embolized mass with less than 150 ml blood loss. For coverage of the soft tissue defect, a dilatated submandibular artery and external jugular vein were selected as the recipient vessels on the ipsilateral side. An anterolateral thigh flap, 25 × 15 cm in size and 15 mm in thickness, was obtained from the left thigh, and the fatty tissue of the flap was resected to make a thin flap of adequate thickness. After the flap was transferred to the prepared defect, the pedicle vessel of this flap was anastomosed directly to the left submandibular artery and external jugular vein. The donor defect was closed with a mesh skin graft. Finally, the total blood loss for this surgery was 500 ml, and no blood transfusion was needed.

The postoperative course was uncomplicated and there was no flap necrosis. Temporary postoperative facial palsy resulting from damage to the left marginal mandibular branch occurred temporarily. Now, 7 years after surgery, there has been no reexpansion of the malformation. Additional surgical correction, including defatting of the flap and facial reanimation, was unnecessary, and no problems arose with the donor site (Fig 1).

Patient 2

A 44-year-old woman had an AVM on the left cheek that had appeared during childhood and was characterized by repeated bleeding. Ten years previously, it grew in size, and she experienced cerebral ischemic attack sometimes. Embolization and sclerotherapy without resection were performed, but the results were insufficient. In July 1998, uncontrollable bleeding occurred and the patient was referred to our unit.

Preoperative superselective transarterial embolization of the left external carotid artery with titanium coils and polyvinyl alcohol particles was performed, and the malformation showed little pulsation with no skin necrosis. Five days after embolization, surgery was performed.

En block resection of the malformation leaving upper lip mucosa was very easy, with blood loss of 150 ml. The left superior thyroid artery and the facial vein were prepared as the recipient vessels. In accordance with the patient's desire, a deep inferior epigastric artery perforator (DIEP) flap with a split rectus abdominis muscle, 14 × 9 cm, was obtained from the left lower abdominal wall. The motor nerve in the split muscle was dissected proximally to the intercostal nerve. Thinning of a DIEP flap can be performed by resecting the fatty tissue from the deep layer of the flap (Figs 1 and 2). A free thin DIEP flap with a split rectus abdominis muscle can be obtained with transaction of the proximal portion of the deep inferior epigastric vessel. The vessels of this flap were anastomosed to the left superior thyroid artery with a saphenous vein graft and the facial vein without vein graft. The motor nerve of the split muscle was sutured to the transected end of the left buccal branch of the facial nerve. The donor defect was closed directly. Total bleeding of 250 ml occurred, and there was no need for blood transfusion. Now, 4 years after surgery, the patient can smile with the use of the transferred split muscle. She has had no abdominal hernias, no weakness, no bulging, no related lumbago at the donor site, and little reexpansion of the malformation (Fig 2).

Discussion

Selective embolization as a single treatment method rarely is successful with high-flow anomalies because of the establishment of new pathways of flow. Radical resection is essential for effective treatment. There have been several reports concerning surgical resection after selective arterial embolization. In 1981, Leikensohn et al[5]

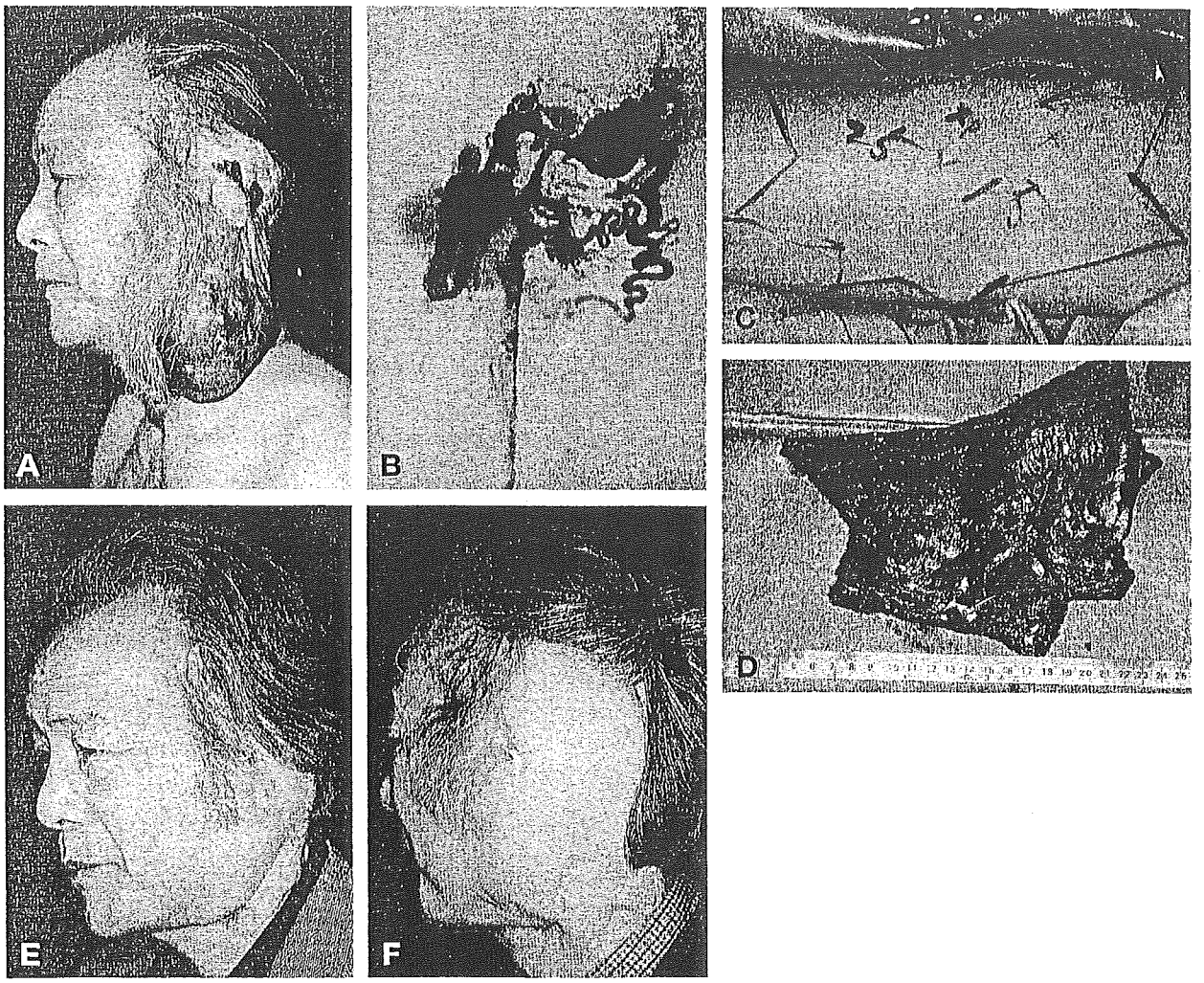

Fig 1. (A) Patient 1. A 64-year-old man with an extensive arteriovenous malformation involving the left cervical and temporal regions. (B) Arteriogram shows a large arteriovenous malformation. (C) Anterolateral thigh flap outlined on the left thigh. (D) Harvested skin flap with pedicle vessels. (E,F) Seven years after surgery. No reexpansion of the malformation and excellent color match.

reported six patients with severe AVMs of the head and neck regions who underwent surgical resection after superselective embolization with apparent lack of recurrence. Also, in 1981, Schrudde and Petrovici[6] demonstrated excellent results in seven patients with voluminous AVMs of the face. They were removed after selective embolization. The defects were closed with split-skin grafting in the area of the forehead, full-thickness grafting in lid reconstruction, rotated skin flaps in the area of the cheek, and with Estlander's procedure for reconstruction of the upper lip. We believe reexpansion would not have been prevented by this conventional coverage. In 1994, Yamamoto et al[7] reported treatment of 14 patients with relatively small AVMs with surgical resection followed by well-vascularized tissue transfer, 12 by free flaps, and two by axial local flaps. Twelve of these 14 patients (86%) attained "great palliation" with an average follow-up of 38 months. However, the AVMs in their series were smaller and only one case required preoperative embolization. In 1998, Kohout et al[8] analyzed their experience with 81 patients who had large head and neck AVMs, including 11 cases treated by superselective embolization and free-flap repair. Weinzweig et al[1] reported a case of a large AVM treated with selective intra-arterial embolization, surgical resection, and composite free tissue transfer (radial forearm flap) with a 1-year follow-up.

Jackson et al[9] and Mulliken and Glowacki[10]