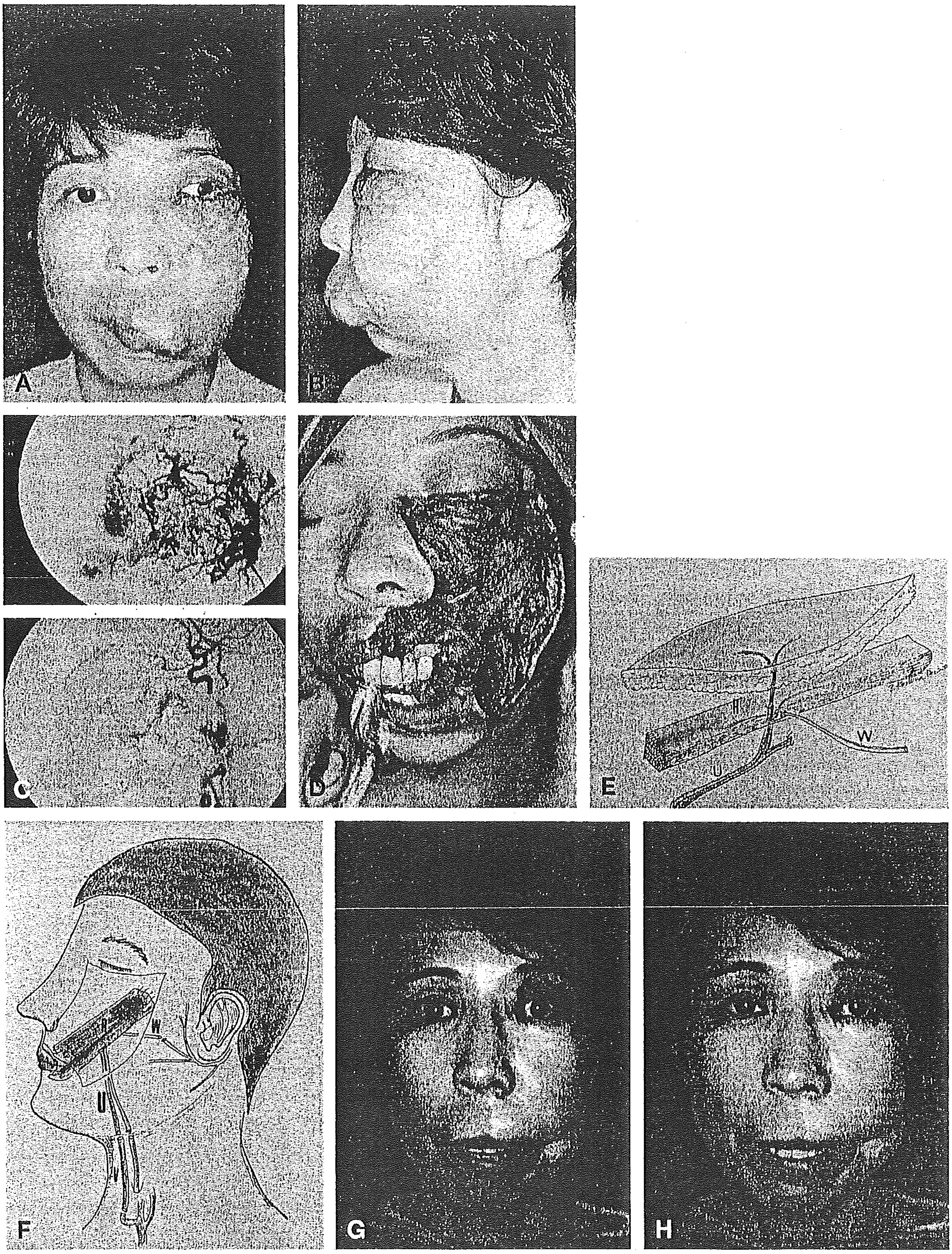

Fig 2. (A,B) Patient 2. A 44-year-old woman had an arteriovenous malformation on the left cheek. (C) Preoperative angiograms before and after superselective embolization. Top, before the embolization; bottom, after the embolization. (D) En block resection of the malformation with a blood loss of 150 ml. (E) Transferred deep inferior epigastric artery perforator flap with a split rectus abdominis muscle. (F) Schematic drawing of the reconstruction. U, deep inferior epigastric vessel; M, split muscle; W, motor branch of the intercostals nerve; V, saphenous vein graft. (G,H) No reexpansion of the malformation at 3.5 years after surgery.

noted that AVMs become apparent a short time after ligation, incomplete embolization, or partial resection because of reorientation of the blood supply and changed hemodynamics. These AVMs lead to recurrences that often are larger than the primary lesion. Mitchell and Taylor[11] also reported that limited surgical resection cannot prevent a reexpansion of the malformation in long follow-ups. Despite advances in recent radiologic and surgical techniques, AVMs continue to present notoriously difficult clinical problems. Even with selective embolization, complete resection of AVMs in the head and neck is usually difficult because of the complex anatomy of this region and the cosmetic implication of radical treatment. We presented patients without reexpansion of the remaining malformation in a long follow-up of from 4 to 7 years after resection. Based on our cases of huge AVMs, the key points to prevent reexpansion over a long period are extensive superselective embolization by a neurosurgical specialist, extensive wide and deep surgical resection, and reconstruction of any severely disfigured facial contour and reanimation with sophisticated microsurgical tissue transfers.

The waiting time for resection after embolization seems to be very important, because the possibility of total resection depends on the results of embolization. Kohout et al[8] recommended the resection should be performed within 24 to 48 hours after embolization because in several cases, rapid expansion occurred during the period between embolization and resection. Jackson et al[9] recommended resection within 24 to 48 hours after embolization and considered that the optimal treatments should consist of a careful assessment and good embolization followed by total resection within 48 hours. Mulliken[10] used a combined treatment consisting of highly selective embolization followed by complete resection after an interval of 1 to 14 days for most symptomatic AVMs. It has become their policy to resect AVMs within 24 to 48 hours of embolization. In 1998, Mulliken's cases had shown little reexpansion 3 to 7 years after surgery. We recommend that resection should be performed from 5 days to 6 weeks after embolization, because in cases of insufficient embolization, reexpansion occurs during the early days after embolization. In cases of effective embolization, recirculation of the malformation does not occur within 6 weeks. Based on our cases, even when resection is performed at longer periods after embolization, there is little surgical bleeding.

Another important factor to be considered to prevent reexpansion of malformations is the reconstructive method used to cover the defects after resection. When a skin graft is used, postoperative changes in the vascularity and fibrosis of the wound contribute further to the ischemic environment, and subsequently, the lesion may recur.[7,12] Although reexpansion or recurrence may occur because of an incomplete resection, not a skin graft, we believe free tissue transfers can provide an excellent solution for restoring these complex defects. A highly vascularized free flap may impact the histologic change of the AVMs by blocking the vicious cycle of ischemia and anatomic replacement of disfigured skin and subcutaneous tissues.[12] In 1981, Hurwitz and Kerber[13] wrote that the replacement of AVMs with well-vascularized tissue should improve the local hemodynamics and provide long-term palliation. Mulliken[10] also observed that microvascular tissue transfers permit wide resection of malformations and optimize the vascularity. Furthermore, residual malformation adjacent to a free flap can remain quiescent. Tark and Chung[12] reported on three patients who had long-standing high-flow vascular malformations of the face and scalp who underwent preoperative embolization and a free-flap transfer after near-total excision of the lesion.

Regarding the flap selection for repair of defects, perforator flaps, such as the anterolateral thigh[14] and DIEP flaps,[15] are suitable for these massive defects in the head and neck regions. These perforator flaps have the advantages of a large skin territory with minimal morbidity, and the operating time for flap elevation is bloodless and short. In addition, the flap can be made into a thin flap with the removal of fatty tissue.[14,16] Simultaneous flap elevation with resection is also possible because the donor sites are far from the recipient side. The DIEP flap with preservation of rectus muscle function has been indicated especially for children and young women who expect to have children. With the use of this flap, minimal invasive reconstruction is possible, thus avoiding abdominal bulging, lateral shifting of the oblique muscle, and abdominal herniation. These have recently been reported as complications of the rectus abdominis musculocutaneous flap. In addition, in cases of zygomatic muscle loss, the DIEP flap has the potential for dynamic reconstruction of facial reanimation when used in combination with a split muscle segment with motor nerves for facial reanimation.

The difficult point in reconstruction with this method is the selection of recipient vessels because of arterial obstruction near the lesion as a result of embolization. In patient 2, we needed a vein graft because the arteries in facial region were totally obstructed by repeated embolizations.

Finally, the management of AVMs mandates a comprehensive team approach, including a neurosurgeon specializing in vascular intervention. Jackson et al[9] noted that patients need to be treated by a team of experts including a plastic surgeon, a vascular radiologist, a hematologist, an anesthesiologist, a dental prosthetist, a psychologist, a social worker, and others.

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References

1 Weinzweig N, Chin G, Polley J, et al. Arteriovenous malformation of the forehead, anterior scalp, and nasal dorsum. *Plast Reconstr Surg.* 2000;105:2433.
2 Halstead WS. Congenital arteriovenous and lymphaticovenous fistulae. *Tr Am Surg A.* 1919;37:262.
3 Brooks B. The treatment of traumatic arterio-venous fistula. *South Med J.* 1930;23:100.
4 Djindjian R, Cophignon J, Theron J, et al. Embolization by superselective arteriography from the femoral route in neuroradiology. Review of 60 cases: 1. Technique, indications, complications. *Neuroradiology.* 1973;6:20.
5 Leikensohn JR, Epstein LI, Vasconez LO. Superselective embolization and surgery of noninvoluting hemangiomas and A-V malformations. *Plast Reconstr Surg.* 1981; 68:143.
6 Schrudde J, Petrovici V. Surgical treatment of giant hemangioma of the facial region after embolization. *Plast Reconstr Surg.* 1981;68:878.
7 Yamamoto Y, Ohura, T, Minakawa H, et al. Experience with arteriovenous malformations treated with flap coverage. *Plast Reconstr Surg.* 1994;94:476.
8 Kohout MP, Hansen M, Pribatz JJ, et al. Arteriovenous malformations of the head and neck: natural history and management. *Plast Reconstr Surg.* 1998;102:643–654.
9 Jackson IT, Carreno R, Potparic, Z, et al. Hemangiomas, vascular malformations, and lymphvenous malformations: classification and methods of treatment. *Plast Reconstr Surg.* 1993;91:1216.
10 Mulliken JB, Glowacki J. Hemangiomas and vascular malformations in infants and children: a classification based on endothelial characteristics. *Plast Reconstr Surg.* 1982; 69:412.
11 Mitchell EL, Taylor GI, Houseman ND, et al. The angiosome concept applied to arteriovenous malformations of the head and neck. *Plast Reconstr Surg.* 2001;107: 633.
12 Tark KC, Chung S. Histologic change of arteriovenous malformations of the face and scalp after free flap transfer. *Plast Reconstr Surg.* 2000;106:87.
13 Hurwitz DJ, Kerber CW. Hemodynamic considerations in the treatment of arteriovenous malformations of the face and scalp. *Plast Reconstr Surg.* 1981;67:421.
14 Koshima I, Fukuda H, Yamamoto H, et al. Free anterolateral thigh flaps for reconstruction of head and neck defects. *Plast Reconstr Surg.* 1993;92:421.
15 Koshima I, Soeda S. Inferior epigastric artery skin flaps without rectus abdominis muscle. *Br J Plast Surg.* 1989; 42:645.
16 Koshima I, Moriguchi T, Soeda S, et al. Free thin paraumbilical perforator-based flaps. *Ann Plast Surg.* 1992;29:12.

Neurovascular Free-Muscle Transfer for the Treatment of Established Facial Paralysis following Ablative Surgery in the Parotid Region

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Neurovascular free-muscle transfer for facial reanimation was performed as a secondary reconstructive procedure for 45 patients with facial paralysis resulting from ablative surgery in the parotid region. This intervention differs from neurovascular free-muscle transfer for treatment of established facial paralysis resulting from conditions such as congenital dysfunction, unresolved Bell palsy, Hunt syndrome, or intracranial morbidity, with difficulties including selection of recipient vessels and nerves, and requirements for soft-tissue augmentation. This article describes the authors' operative procedure for neurovascular free-muscle transfer after ablative surgery in the parotid region. Gracilis muscle (n = 24) or latissimus dorsi muscle (n = 21) was used for transfer. With gracilis transfer, recipient vessels comprised the superficial temporal vessels in 12 patients and the facial vessels in 12. For latissimus dorsi transfer, recipient vessels comprised the facial vessels in 16 patients and the superior thyroid artery and superior thyroid or internal jugular vein in four. Facial vessels on the contralateral side were used with interpositional graft of radial vessels in the remaining patient with latissimus dorsi transfer. Cross-face nerve grafting was performed before muscle transfer in 22 patients undergoing gracilis transfer. In the remaining two gracilis patients, the ipsilateral facial nerve stump was used as the primary recipient nerve. Dermal fat flap overlying the gracilis muscle was used for cheek augmentation in one patient. In the other 23 patients, only the gracilis muscle was used. With latissimus dorsi transfer, the ipsilateral facial nerve stump was used as the recipient nerve in three patients, and a cross-face nerve graft was selected as the recipient nerve in six. The contralateral facial nerve was selected as the recipient nerve in 12 patients, and a thoracodorsal nerve from the latissimus dorsi muscle segment was crossed through the upper lip to the primary recipient branches. A soft-tissue flap was transferred simultaneously with the latissimus muscle segment in three patients. Contraction of grafted muscle was not observed in two patients with gracilis transfer and in three patients with latissimus dorsi transfer. In one patient with gracilis transfer and one patient with latissimus dorsi transfer, acquired muscle contraction was excessive, resulting in unnatural smile animation. The recipient nerves for both of these patients were the ipsilateral facial nerve stumps, which were dissected by opening the facial nerve canal in the mastoid process. From the standpoint of operative technique, the one-stage transfer for latissimus dorsi muscle appears superior. Namely, a combined soft-tissue flap can provide sufficient augmentation for depression of the parotid region following wide resection. A long vascular stalk of thoracodorsal vessels is also useful for anastomosis, with recipient vessels available after extensive ablation and neck dissection. (*Plast. Reconstr. Surg.* 113: 1563, 2004.)

Although many articles have described immediate facial nerve reconstruction following ablative surgery in the parotid region,[1–7] secondary facial nerve reconstruction has received little attention. In primary settings, when a nerve defect that precludes direct nerve suture is evident, nerve grafting and cross-facial nerve grafting are possible options.[8–10] However, cosmetic results achieved with these procedures, particularly with regard to smile function, can be poor because of synkinesis or weak recovery of mimetic muscles, resulting in the need for alternative methods of secondary reconstruction of facial paralysis. Secondary reconstruction is also required in cases where facial paralysis has

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persisted for 1 year or more despite preservation of the continuity of the facial nerve during ablative procedures.

To treat patients with long-standing facial paralysis, we have applied neurovascular muscle transfer to obtain facial reanimation. The intervention differs from those for established facial paralysis resulting from conditions such as congenital dysfunction, Bell palsy, Hunt syndrome, or intracranial seventh nerve damage. This is because ablative surgery of the parotid region frequently results in a soft-tissue defect, which should be restored using a soft-tissue flap combined with the neurovascular free-muscle transfer. Moreover, selection of recipient nerves and vessels can be complicated by previous ablative surgery or intraarterial chemotherapy. The present study describes the operative procedure for neurovascular free-muscle transfer after ablative surgery in the parotid region and demonstrates some representative cases. In our series, either the gracilis or latissimus dorsi muscle was transferred in all cases. Differences between the two operative procedures and the results are also discussed.

Patients and Methods

Patient Profiles

Between November of 1981 and February of 2001, neurovascular free-muscle transfer was performed in 45 patients with facial paralysis following ablative surgery in the parotid region. Patients ranged in age from 5 to 65 years (mean, 34.2 years) at the time of neurovascular free-muscle transfer. Facial paralysis was incomplete in 14 of the 45 patients. Ancillary procedures accompanying neurovascular free-muscle transfer included temporal muscle transfer for eyelid closure in 20 patients, lid loading using a gold plate for the upper eyelid in five, eyebrow lift in 17, and blepharoplasty in six.

Operative Technique

In almost all cases, a preauricular incision was used for primary ablative surgery. This incision was then reused to create a subcutaneous cheek pocket to accept subsequent neurovascular muscle transfer. Recipient vessels were then prepared. The superficial temporal or facial vessels were predominantly used. However, when these vessels were unsuitable for vascular anastomosis because of previous ablative operation, chemotherapy, irradiation, or other such reasons, other vessels in the ipsilateral upper neck were used. If vessels in the ipsilateral neck were unavailable, contralateral vessels were selected as recipients. Vascular grafting was sometimes required in such cases.

Selection of the recipient nerve depends on the condition of the residual ipsilateral facial nerve. When the ipsilateral facial nerve stump was available, it was used as a motor source for innervating transferred muscle.[11] When the ipsilateral facial nerve was unavailable because of the location of the nerve stump deep in the facial nerve canal, contralateral facial nerve branches were used as recipients. In the early cases of our present series, a two-stage method combining neurovascular free-muscle transfer with cross-face nerve grafting[12] was performed. In the first stage of this method, a sural nerve graft between the intact side and paralyzed cheek was used. Approximately 1 year later, the selected muscle (predominantly gracilis, but also latissimus dorsi in some cases) was transferred in the second operation. The motor nerve of the transferred muscle was sutured to the stump of the cross-face nerve graft. After approximately 1995, a one-stage method using latissimus dorsi muscle has been used more commonly.[13] The thoracodorsal nerve of latissimus dorsi was crossed through the upper lip and sutured to a contralateral facial nerve branch in one operation.

When soft-tissue defects required reconstruction because of extensive tumor resection, a soft-tissue flap was simultaneously performed with neurovascular free-muscle transfer. Musculocutaneous flaps using gracilis, latissimus dorsi, or serratus anterior were used for restoration of facial contour in our present series.

Transferred Muscle

Gracilis was used in 24 of the 45 patients, and latissimus dorsi was used in 21.

Selected Recipient Vessels

When gracilis was transferred, recipient vessels comprised superficial temporal vessels in 12 patients and facial vessels in 12. When latissimus dorsi was transferred, recipient vessels comprised facial vessels in 16 patients, the superior thyroid artery and superior thyroid or internal jugular vein in four, and contralateral facial vessels with interpositional graft of the radial vessels in one. In this last patient, ipsilateral vessels were unavailable because of previous ablative operation, radical neck resection, and rectus abdominis musculocutaneous flap transfer for coverage of a skin defect following cancer ablation.

Selected Recipient Nerves

When gracilis was used, cross-face nerve grafting was performed before muscle transfer in 22 patients, whereas the ipsilateral facial nerve stump was used as the recipient nerve in the remaining two. When latissimus dorsi was used, recipient nerves comprised the ipsilateral facial nerve stump in three patients and the cross-face nerve graft stump that had been grafted before muscle transfer in six. In 12 patients, the thoracodorsal nerve of the latissimus dorsi muscle, approximately 15 to 16 cm long, was crossed through the upper lip and sutured to contralateral facial nerve branches exposed anterior to the parotid grand.

Soft-Tissue Augmentation

When gracilis was used, a dermal fat flap overlying the muscle was used for cheek augmentation in one patient. Gracilis was used solely for facial reanimation in the other 23 patients, without soft-tissue augmentation in the parotid region. When latissimus dorsi was used, a dermal fat flap overlying the muscle was transferred simultaneously with the muscle segment in one patient. A deepithelialized serratus anterior musculocutaneous flap nourished by a common trunk with the thoracodorsal nutrient vessels of the latissimus dorsi was transferred in two patients for cheek augmentation.

Evaluation

The aims of this operative procedure were reconstruction of a natural or near-natural smile and augmentation of the depressed cheek with soft tissue. The grading scales shown in Table I were used to evaluate smile reconstruction.

RESULTS

In two patients with gracilis transfer and three patients with latissimus dorsi transfer, voluntary contraction of grafted muscle was not observed. In one patient with gracilis transfer and one patient with latissimus dorsi transfer, acquired muscle contraction was excessive, resulting in unnatural animation of the smile. In both cases, recipient nerves were ipsilateral facial nerve stumps that had been dissected by opening the facial nerve canal in the mastoid process.

Smile results for patients with gracilis transfer were evaluated as grade 5 in 10 patients (42 percent), grade 4 in 10 patients (42 percent), grade 3 in two patients (8 percent), and grade 1 in two patients (8 percent). Results for latissimus dorsi transfer were evaluated as grade 5 in nine patients (43 percent), grade 4 in eight patients (38 percent), grade 3 in one patient (5 percent), and grade 1 in three patients (14 percent).

CASE REPORTS

Case 1

A 43-year-old man presented with complete left facial paralysis resulting from ablative surgery of facial nerve schwannoma in the parotid gland 1 year previously (Fig. 1). The one-stage method using latissimus dorsi muscle was planned for smile reanimation. A preauricular incision from the previous operation was reused to create a subcutaneous cheek pocket to accept subsequent latissimus dorsi transfer. Because detailed information from the previous ablative surgery was unavailable, the ipsilateral facial nerve was not used and the contralateral facial nerve branches were selected as recipient nerves. The facial vessels were used as recipient vessels. After transfer of the latissimus dorsi, endoscopic eyebrow lift was performed for eyebrow ptosis, and the upper eyelid was

TABLE I
Evaluation Criteria

Grade	Description
5	Symmetric balance and good facial tone at rest; sufficient muscle power on voluntary contraction; synchronous and natural expression on emotional facial movements, especially on smiling; EMG demonstrating relatively high amplitudes, with full interference patterns and high evoked potential obtained on stimulation of the contralateral facial nerve
4	Symmetric balance and good facial tone at rest; active muscle contraction acquired but not sufficiently synchronous (too strong or slightly weak); EMG demonstrating good interference patterns and evoked potentials; results well accepted by the patient
3	Symmetric balance and good facial tone at rest; insufficient contraction of the muscle; low volitional EMG spikes with discrete interference patterns
2	Reduced symmetric balance on smiling; no effective contraction of the muscle; EMG with no interference patterns
1	No correction; electrically silent EMG
0	No follow-up

EMG, electromyography.

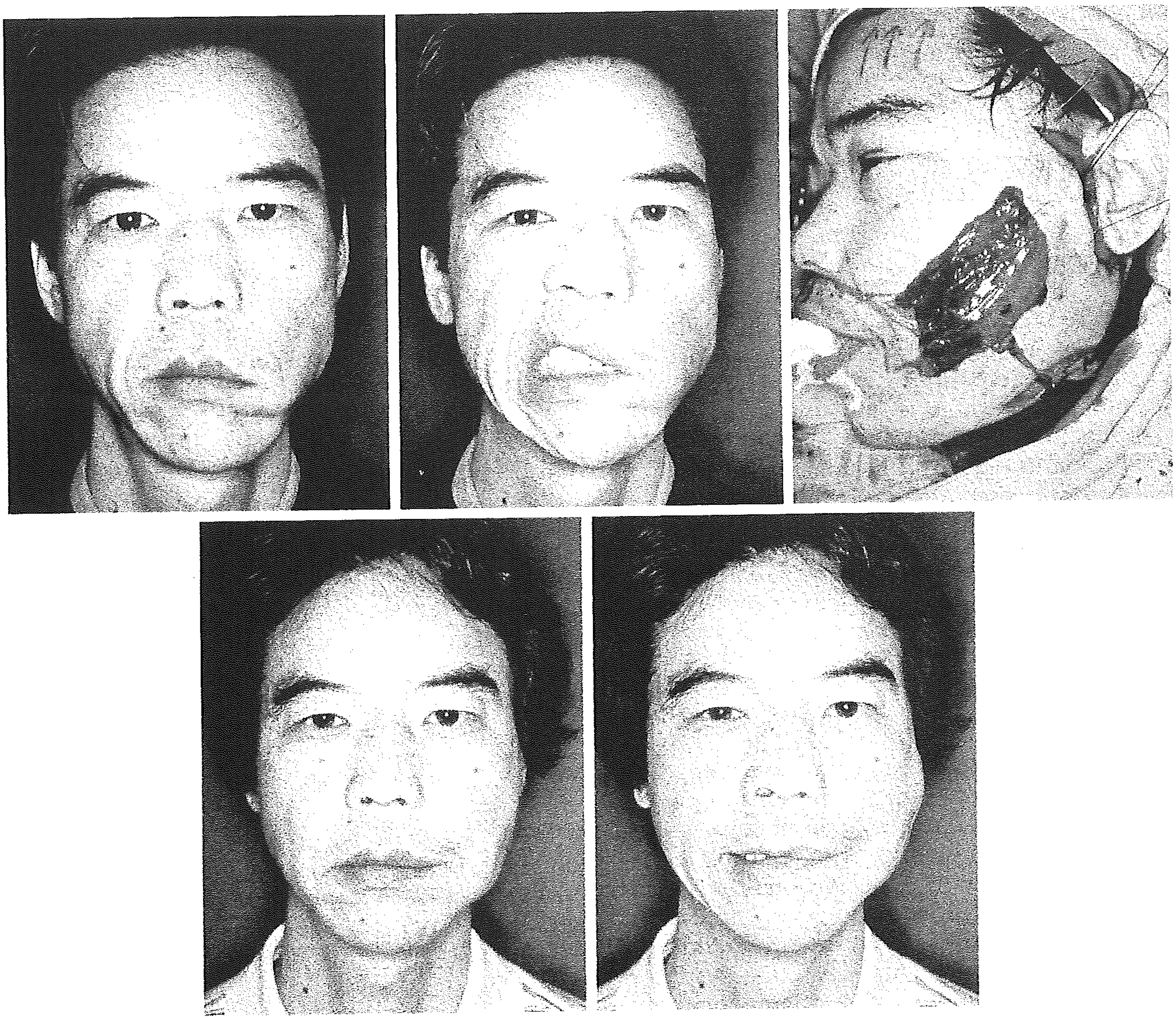

FIG. 1. A 43-year-old man with complete left facial paralysis caused by ablative surgery of facial nerve schwannoma. Preoperative appearance at rest (*above, left*) and smiling (*above, center*). (*Above, right*) The latissimus dorsi muscle was transferred into a cheek pocket. The contralateral facial nerve branches were selected as recipient nerves and the facial vessels were used as recipient vessels. (*Below*) Five-year postoperative appearance at rest and smiling after surgical revision that was performed 2 years after the neurovascular free-muscle transfer.

loaded with a gold plate for eye closure. Muscle contraction was first recognized 6 months after neurovascular free-muscle transfer. Surgical revision to change the position of muscle attachment was performed 2 years after neurovascular free-muscle transfer. As of 5 years after neurovascular free-muscle transfer, smile result was grade 5.

Case 2

A 49-year-old man presented with complete right facial paralysis resulting from radical parotidectomy and partial mandibulectomy for recurrent mucoepidermoid carcinoma of the parotid gland (Fig. 2). No radiotherapy or chemotherapy had been performed before facial nerve reconstruction. Because the ipsilateral facial nerve was located in the facial nerve canal of the temporal bone, contralateral facial nerve branches were used as recipient nerves. In the first operation, a cross-face nerve graft using a sural nerve segment was grafted through the chin, with concomitant transfer of temporal muscle to the eyelids for eye closure and juxta-brow excision for brow lift. Ten months later, when Tinel's sign had advanced to the end of the grafted nerve, neurovascular free-muscle transfer was performed. Because a depressed deformity of the parotid region was evident following the ablative surgery, a deepithelialized serratus anterior musculocutaneous flap was transferred for soft-tissue augmentation in combination with a latissimus dorsi musculocutaneous flap for facial reanimation. The thoracodorsal vessels nourishing both flaps were anastomosed to the facial vessels and the thoracodorsal nerve was sutured to the cross-face nerve stump. As of 2 years 4 months after neurovascular free-muscle transfer, the patient was satisfied with the results after secondary corrective surgery in which transferred muscle was shortened at the nasolabial fold line. Because the transferred muscle is still weak, the smile result was grade 4.

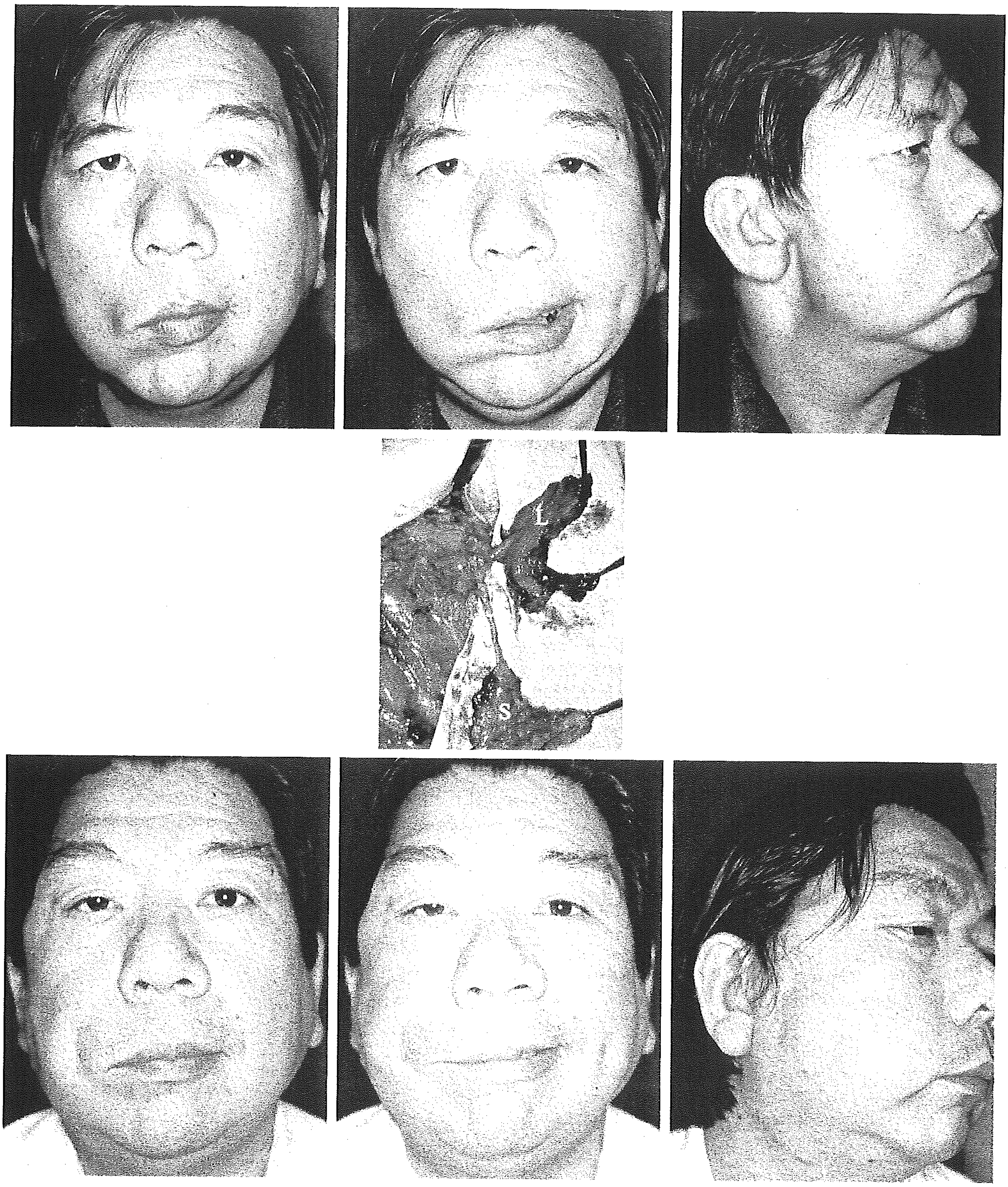

FIG. 2. A 49-year-old man with complete right facial paralysis caused by radical parotidectomy and partial mandibulectomy for recurrent mucoepidermoid carcinoma of the parotid gland. (*Above*) Preoperative appearance at rest and smiling. A depressed deformity of the parotid region was evident. (*Center*) A deepithelialized serratus anterior musculocutaneous flap (*S*) was transferred for soft-tissue augmentation in combination with a latissimus dorsi muscle (*L*) for facial reanimation. (*Below*) Two years 4 months postoperatively; appearance at rest and smiling after secondary corrective surgery.

FIG. 3. A 54-year-old woman with complete right facial paralysis resulting from ablative surgery of squamous cell carcinoma of the right external ear canal. Preoperative appearance at rest and smiling. A severe deformity of the lower face and neck was evident.

Case 3

A 54-year-old woman underwent ablative surgery for squamous cell carcinoma of the right external ear canal (Fig. 3). Resection of the external ear, parotid gland, zygomatic arch, mastoid process, and mandible was performed, along with radical neck dissection. Skin and soft-tissue defects were reconstructed using a rectus abdominis musculocutaneous flap, resulting in complete facial nerve palsy with severe deformity of the lower face and neck. Intraarterial chemotherapy and radiotherapy were performed preoperatively and postoperatively, respectively. One year after ablative surgery, she was referred to us for facial reconstruction. The one-stage method using the latissimus dorsi was planned for facial reanimation. Because vessels suitable for vascular anastomosis were unavailable in the ipsilateral face and neck, contralateral facial vessels were used with an interpositional graft of the radial vessels taken from the left forearm (Fig. 4). Contralateral facial nerve branches were used as recipient nerves. Peripheral Z-plasties to the operative scar of the previous neck dissection and muscle reduction with defatting of the rectus abdominis musculocutaneous flap that had been transferred previously in the ablative surgery were performed simultaneously. Right medial canthal plasty and upper eyelid loading with a gold plate were also performed. As of 1 year 7 months postoperatively, movement of transferred muscle was obtained and the smile result was grade 4 (Fig. 5).

Case 4

A 52-year-old woman presented with complete right facial paralysis following ablative surgery for recurrent pleomorphic adenoma (Fig. 6). Because the ablative surgery had been performed 2 years earlier, neurovascular free-muscle transfer was performed using gracilis for smile reconstruction. The ipsilateral facial nerve stump was initially sought in the scar tissue but could not be found. The mastoid process was then burred to open the facial nerve canal, exposing the proximal stump of the facial nerve for nerve suture. The motor nerve to the gracilis was sutured directly to the facial nerve trunk. Facial vessels were selected as recipients and were anastomosed with the nutrient vessels of the gracilis. The patient presented at our hospital 7 months postoperatively, and excessive contraction of the transferred muscle and bulkiness of cheek skin was evident (grade 4), requiring surgical revision. Transferred muscle was debulked after cheek skin had been undermined to eliminate abnormal facial creases. Furthermore, the nasolabial fold was incised to release the muscular attachment, which was then repositioned using the fascia lata 1 year later. As of 3 years postoperatively, the smile result improved to grade 5.

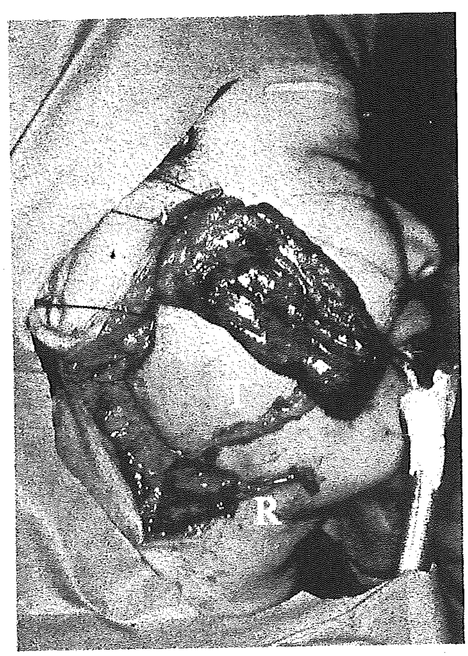

FIG. 4. Because vessels suitable for vascular anastomosis were unavailable in the ipsilateral face and neck, radial vessels (*R*) were interposed between the contralateral facial vessels that were selected as recipients and the thoracodorsal vessels (*T*).

FIG. 5. Postoperative appearance at 1 year 7 months, at rest and smiling. Contour of the lower face and neck was well restored.

DISCUSSION

Since Harii et al.[14] first reported the use of neuromuscular free gracilis muscle transfer for the treatment of long-standing facial paralysis, numerous reconstructive surgeons have used neurovascular free-muscle transfer as the preferred method for treating long-standing facial paralysis.[13,15–18] In our present series, neurovascular free-muscle transfer was successfully used to treat established facial paralysis following ablative surgery in the parotid region. However, several difficulties exist in this kind of facial reconstruction that are not encountered with reconstruction of established facial paralysis resulting from conditions such as congenital dysfunction, unresolved Bell palsy, Hunt syndrome, or intracranial damage.

Fewer vessels are suitable for microvascular anastomoses, because of radical resection during ablative surgery and/or intraarterial chemotherapy. The superficial temporal or facial vessels that are typically selected as recipient vessels are frequently unavailable. Nutrient vessels for the gracilis muscle are not particularly long and cannot reach suitable vessels in the neck. Gracilis should therefore not be used as a donor muscle when superficial temporal or facial vessels are unavailable. Conversely, nutrient vessels for the latissimus dorsi are long enough to reach vessels in the upper neck area such as the superior thyroid vessels. In reconstructions following radical ablation for parotid tumors, particularly those including neck dissection, use of the latissimus dorsi is preferable to gracilis from the perspective of potential recipient vessels.

Attention must be paid to selecting the recipient nerve. In our series, when the ipsilateral facial nerve branch was available, it was used as a motor source for innervating transferred muscle. Of five patients in whom ipsilateral facial nerves were used, two demonstrated excessive muscle contraction resulting in an unnatural appearance during muscle function. The recipient ipsilateral facial nerve stump for both of these patients was exposed by opening the facial nerve canal in the mastoid process, and the facial nerve main trunk was directly sutured to the motor nerve of the transferred muscle. In the remaining three patients in whom a near-natural smile was achieved without unnatural muscle contraction, the muscle motor nerve was sutured to the stumps of facial nerve branches in the cheek. In a previous report, we reported that unnatural muscle contraction was not seen in 39 patients who underwent muscle graft using the facial nerve on the affected side as a motor source.[11] However, the two patients described here were encountered after that report. Chuang et al.[19] presented four cases in which transferred muscle reinnervated using the ipsilateral facial nerve displayed excessive contraction over time. Because local anesthesia can temporarily relieve muscle tightness, they suggested that excessive reinnervation of the muscle appeared largely responsible for such contracture. However, Harrison noted that fibrous tissue created by

FIG. 6. A 52-year-old woman with complete right facial paralysis following parotidectomy for a recurrent pleomorphic adenoma. Preoperative appearance at rest (*above, left*) and smiling (*above, center*). (*Above, right*) The harvested latissimus dorsi muscle was divided into two segments, one of which was inserted into a cheek pocket as a neurovascularized muscle for facial reanimation, and the other of which was used with denervation of the thoracodorsal nerve branch for soft-tissue augmentation in the parotid region. (*Below, left*) Postoperative appearance at 7 months while smiling. Excessive contraction of the transferred muscle and bulkiness of cheek skin was evident. Postoperative appearance at 3 years, at rest (*below, center*) and smiling (*below, right*) after revisional operations including debulking.

surgical dissection and the natural biodegradation that occurs before reinnervation may contract with the muscle.[20] Our results seem to support the excessive reinnervation theory of Chuang et al., as two patients in whom the facial nerve trunk was used as the recipient nerve displayed excessive muscle contraction, whereas three patients in whom facial nerve branches were used as recipient nerves demonstrated natural contraction. The facial nerve trunk might be responsible for excessive innervation of the muscle. In three of four patients (excluding a case of Romberg hemifacial atrophy, in which neurovascular muscle transfer may not have been indicated) reported by Chuang et al., the facial nerve trunk was used as the recipient nerve. We therefore presently believe that when a branch of the ipsilateral facial nerve is available in the cheek, it should be used as a recipient nerve, but we do not recommend use of the facial nerve trunk. The contralateral facial nerve branch should be used when the facial nerve trunk is the only ipsilateral option available.

When depression deformity caused by previous tumor ablation in the parotid region is conspicuous, soft-tissue augmentation is required. As noted before, gracilis muscles were transferred in the early cases of our present series, when latissimus dorsi muscle transfer was not yet developed. However, dermal fat flaps over the gracilis muscle cannot be adequately set into the defect, as the fat flap over gracilis is difficult to elevate separately from the muscle segment as a composite flap. This is the reason why a dermal fat flap in combination with the gracilis muscle was transferred in only one case for soft-tissue augmentation. On the contrary, many authors have reported that the latissimus dorsi flap can be elevated as a combined flap with other flaps such as the serratus anterior flap and the scapular flap on a single pedicle.[21–24] Kimata et al.[25] reported a case of facial reconstruction using a combination of parascapular flap and latissimus dorsi muscle flap for facial reanimation and soft-tissue augmentation in the parotid region. In our series, a deepithelialized serratus anterior musculocutaneous flap was used for two patients. The thoracodorsal vessels divide into branches to nourish both the latissimus dorsi and serratus anterior muscles. The latissimus dorsi and serratus anterior musculocutaneous flap for soft-tissue augmentation can therefore be harvested as a combined flap for facial reanimation and soft-tissue augmentation, respectively.[26] The serratus anterior musculocutaneous flap may therefore represent the best option for combination with latissimus dorsi transfer, as intraoperative repositioning of the patient is not required, unlike when the scapular flap is used.

CONCLUSIONS

The results of this present series show that the latissimus dorsi muscle represents a better choice than the gracilis muscle for the reconstruction of facial paralysis after ablative parotid surgery, from the perspective of recipient vessels and combined soft-tissue flap, even though no significant difference in acquired smile function of the paralyzed face was evident between the two methods. When the contralateral facial nerve is selected as the recipient nerve, gracilis muscle should typically be used in a two-stage procedure with a cross-face nerve graft, although some authors have reported the use of the gracilis muscle in a one-stage method.[27,28] Conversely, the latissimus dorsi muscle is used in a one-stage procedure, as sufficient thoracodorsal nerve can be harvested to reach the contralateral cheek without nerve grafting. As a result, the latissimus dorsi muscle offers the benefit of a shorter recovery period than the two-stage method using the gracilis muscle.[13] Use of the latissimus dorsi muscle is therefore recommended over the gracilis muscle when the ipsilateral facial nerve branch is unavailable.

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REFERENCES

1. Conley, J. J. Facial nerve grafting in treatment of parotid gland tumors. *Arch. Surg.* 70: 359, 1955.
2. Conley, J. J. Facial nerve grafting. *Arch. Otolaryngol.* 73: 322, 1961.
3. Arena, S., Dickinson, J. T., and Cipcic, J. A. Primary reconstruction at time of ablative surgery. *Laryngoscope* 78: 498, 1968.
4. Lee, K. K., and Terzis, J. K. Management of acute extratemporal facial nerve palsy. *Clin. Plast. Surg.* 11: 203, 1984.
5. Vaughan, E. D., and Richardson, D. Facial nerve reconstruction following ablative parotid surgery. *Br. J. Oral Maxillofac. Surg.* 31: 274, 1993.
6. Samii, M., and Matthies, C. Indication, technique and results of facial nerve reconstruction. *Acta Neurochir.* 130: 125, 1994.
7. Reddy, P. G., Arden, R. L., and Mathog, R. H. Facial nerve rehabilitation after radical parotidectomy. *Laryngoscope* 109: 894, 1999.
8. Conley, J., and Baker, D. C. The surgical treatment of extratemporal facial paralysis: An overview. *Head Neck Surg.* 1: 12, 1978.
9. Conley, J., and Baker, D. C. Hypoglossal-facial nerve anastomosis for reinnervation of the paralyzed face. *Plast. Reconstr. Surg.* 63: 63, 1979.
10. Terzis, J. K., and Schnarrs, R. H. Facial nerve reconstruction in salivary gland pathology: A review. *Microsurgery* 14: 355, 1993.
11. Ueda, K., Harii, K., Asato, H., et al. Evaluation of muscle graft using facial nerve on the affected side as a motor source in the treatment of facial paralysis. *Scand. J. Plast. Reconstr. Surg. Hand Surg.* 33: 47, 1999.
12. Harii, K. Refined microneurovascular free muscle transplantation for reanimation of paralyzed face. *Microsurgery* 9: 169, 1988.
13. Harii, K., Asato, H., Yoshimura, K., et al. One-stage transfer of the latissimus dorsi muscle for reanimation of a paralyzed face: A new alternative. *Plast. Reconstr. Surg.* 102: 941, 1998.
14. Harii, K., Ohmori, K., and Torii, S. Free gracilis muscle transplantation, with microneurovascular anastomoses for the treatment of facial paralysis. *Plast. Reconstr. Surg.* 57: 133, 1976.
15. Harii, K. Microneurovascular free muscle transplantation for reanimation of facial paralysis. *Clin. Plast. Surg.* 6: 361, 1979.

16. O'Brien, B. M., Franklin, J. D., and Morrison, W. A. Cross-facial nerve grafts and microneurovascular free muscle transfer for long established facial palsy. *Br. J. Plast. Surg.* 33: 202, 1980.
17. Manktelow, R. T. Free muscle transplantation for facial paralysis. *Clin. Plast. Surg.* 11: 215, 1984.
18. Terzis, J. K. Pectoralis minor: A unique muscle for correction of facial palsy. *Plast. Reconstr. Surg.* 83: 767, 1989.
19. Chuang, D. C., Devaraj, V. S., and Wei, F. C. Irreversible muscle contracture after functioning free muscle transplantation using the ipsilateral facial nerve for reinnervation. *Br. J. Plast. Surg.* 48: 1, 1995.
20. Harrison, D. H. Irreversible muscle contracture after functioning free muscle transfer for facial palsy. *Br. J. Plast. Surg.* 48: 518, 1995.
21. Harii, K., Ono, I., and Ebihara, S. Closure of total cheek defects with two combined myocutaneous free flaps. *Arch. Otolaryngol.* 108: 303, 1982.
22. Hirase, Y., Kojima, T., Kinoshita, Y., et al. Composite reconstruction for chest wall and scalp using multiple ribs-latissimus dorsi osteomyocutaneous flaps as pedicled and free flaps. *Plast. Reconstr. Surg.* 87: 555, 1991.
23. Penfold, C. N., Davies, H. T., Cole, R. P., et al. Combined latissimus dorsi-serratus anterior/rib composite free flap in mandibular reconstruction. *Int. J. Oral Maxillofac. Surg.* 21: 92, 1992.
24. Netscher, D., Alford, E. L., Wigoda, P., and Cohen, V. Free composite myo-osseous flap with serratus anterior and rib: Indications in head and neck reconstruction. *Head Neck* 20: 106, 1998.
25. Kimata, Y., Tsukada, S., Iwamoto, T., and Harii, K. Free combined parascapular flap and latissimus dorsi muscle flap for facial palsy and neck reconstruction. *Br. J. Plast. Surg.* 48: 515, 1995.
26. Harii, K., Yamada, A., Ishihara, K., et al. A free transfer of both latissimus dorsi and serratus anterior flaps with thoracodorsal vessel anastomoses. *Plast. Reconstr. Surg.* 70: 620, 1982.
27. Kumar, P. A. Cross-face reanimation of the paralysed face, with a single stage microneurovascular gracilis transfer without nerve graft: A preliminary report. *Br. J. Plast. Surg.* 48: 83, 1995.
28. Kumar, P. A., and Hassan, K. M. Cross-face nerve graft with free-muscle transfer for reanimation of the paralyzed face: A comparative study of the single-stage and two-stage procedures. *Plast. Reconstr. Surg.* 109: 451, 2002.

SURGICAL MANAGEMENT OF MAXILLECTOMY DEFECTS BASED ON THE CONCEPT OF BUTTRESS RECONSTRUCTION

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Abstract: *Background.* Few published large series have described a surgical approach to maxillary skeletal reconstruction on the basis of the extent of maxillectomy.

Methods. We have reviewed a 10-year experience with 38 consecutive maxillary reconstructions with respect to maxillectomy defects, reconstructive procedures, reconstructed buttresses, and functional and aesthetic outcomes.

Results. Maxillectomy defects were classified into three categories on the basis of the buttress concept. Buttress reconstruction was most frequently performed in category III maxillary defects (56%), followed by category I (50%) and category II (20%). The vascularized composite autograft included the rectus abdominis myocutaneous free flap combined with costal cartilage, and the latissimus dorsi myocutaneous free flap combined with the V-shaped scapula is an effective method for reliable reconstruction of both skeletal and soft tissues.

Conclusions. A critical assessment for skeletal defects and associated soft tissue defects is essential for an adequate approach to solve complex problems in maxillary reconstruction. On the basis of retrospective analysis of this series, a reconstructive algorithm for surgical management of maxillectomy defects is proposed. © 2004 Wiley Periodicals, Inc. *Head Neck* **26:** 247–256, 2004

Keywords: maxillary reconstruction; maxillary buttress; maxillectomy defect; vascularized composite autograft; microsurgical tissue transfer

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Oncologic resection of the maxilla, paranasal sinuses, palate, zygoma, and orbit causes significant functional and aesthetic defects. These may result in collapse of infraorbital and malar composite tissues, several orbital complications, loss of the hemipalate, and difficulty with speech and mastication. The advent of microsurgical techniques has greatly benefited reconstruction of the complex maxillectomy defect; however, some of the problems associated with reconstructive approaches for soft tissue replacement alone remain.[1–3]

At the Hokkaido University Hospital and affiliated hospitals, maxillectomy defects after extensive ablation of tumors have been reconstructed on the basis of the principles of repair involving an important concept of maxillary buttress reconstruction.[4] The midfacial structure consists of

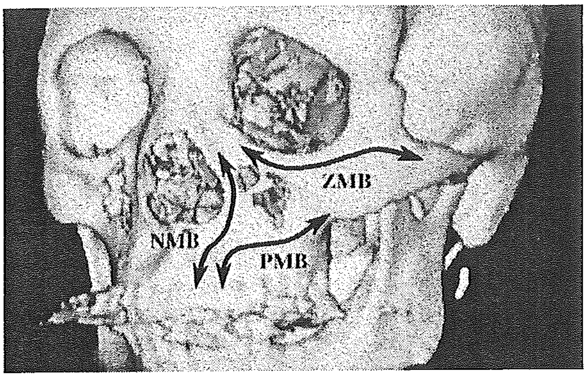


FIGURE 1. Three maxillary buttresses in the surgical management of maxillary skeletal defects. ZMB, zygomaticomaxillary buttress; PMB, pterygomaxillary buttress; NMB, nasomaxillary buttress.

three principal maxillary buttresses: the zygomaticomaxillary (ZMB), pterygomaxillary (PMB), and nasomaxillary buttresses (NMB). The ZMB extends from frontal process of maxilla along the inferior ridge of the orbit to the zygomatic process of the frontal bone and laterally to the zygomatic arch. The PMB extends from the alveolar ridge anterior to the pterygoid plate of the sphenoid bone. The NMB extends from the anterior maxillary alveolus along the piriform aperture to the nasal process of the maxilla (Figure 1). Restoration of these buttresses is a rational approach to obtain the most effective reconstruction of complex maxillectomy skeletal defects.

Herein the senior author's experience with 38 consecutive patients is represented. The objective of this study was to review these reconstructive cases with respect to maxillectomy defects, reconstructive procedures, reconstructed buttresses, and functional and aesthetic outcomes. A reconstructive algorithm for surgical management of maxillectomy defects on the basis of the concept of buttress reconstruction was also devised.

PATIENTS AND METHODS

From October 1992 to July 2002, 38 patients with maxillectomy defects were reconstructed by the senior author (YY). The mean patient age at the time of the surgery was 58 years, with a range from 26 to 78 years. There were 28 men and 10 women. On pathologic examination of the primary tumor, squamous cell carcinoma was the most common tumor type (76%).

Maxillectomy Defects. Maxillectomy defects were grouped into one of three categories on the basis of our retrospective assessment for anatomic sites of resection. Category I included limited maxillectomy and subtotal maxillectomy defects. In this category, the anterior and/or medial walls of the lower maxilla, including the palate, are mainly removed with preservation of the orbital inferior ridge and floor. According to the buttress concept, the PMB and partial NMB are ablated (Figure 2A). Category II included orbitomaxillectomy and orbitozygomatic maxillectomy defects. In this category, the anterior and medial walls of the upper maxilla, including the orbital contents (orbital exenteration), are mainly removed with preservation of the palate. The malar region, including the zygomatic arch, is occasionally resected in an orbitozygomatic maxillectomy. According to the buttress concept, the ZMB and partial NMB are ablated (Figure 2B). Category III included total maxillectomy and extended to total maxillectomy defects. In this category, the maxilla is completely removed without preservation of the orbital inferior ridge and floor and the palate. The orbital contents (orbital exenteration), malar region including zygomatic arch, and/or facial skin and/or mimetic muscle are occasionally resected in an extended total maxillectomy. According to the buttress concept, the ZMB, PMB, and NMB are ablated (Figure 2C). In this series, the maxillary defects of six patients (16%) were defined as category I, of five patients (13%) as category II, and of 27 patients (71%) as category III (Table 1).

Reconstructive Procedures. In this series, 19 patients (50%) underwent only soft tissue reconstruction. The reconstructed sites of soft tissue included the palatal roof, lateral wall of the nasal cavity, eye socket, and facial skin. The rectus abdominis myocutaneous free flap was the most commonly used in 13 patients, followed by the radial forearm free flap in 3 patients. Twelve of 13 rectus abdominis myocutaneous/muscle free flaps were used for the patients with a category III maxillectomy defect. The temporalis muscle flap and temporoparietal fascial flap were mainly applied for a category II maxillectomy defect. On the other hand, the remaining 19 patients (50%) underwent simultaneous reconstruction of skeletal and soft tissues. The reconstructed sites of skeletal tissue included the ZMB, PMB, and NMB on the basis of the concept of buttress reconstruction. Vascularized composite autograft was used for 17 of 19 patients with simultaneous reconstruction of skeletal and soft tissues. In the early stage of this series, three-dimensionally contoured pieces of titanium mesh were used in two patients. In this series, neither nonvascularized bone nor

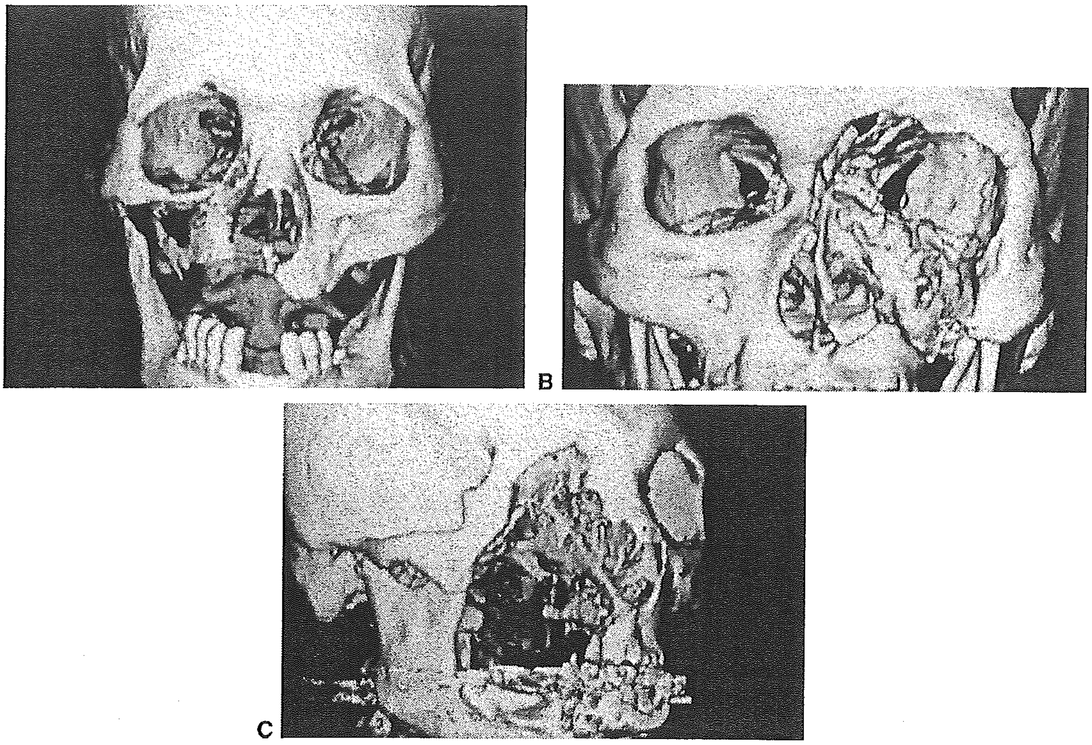


FIGURE 2. (A) Category I of maxillectomy defect in three-dimensional CT scan. PMB and NMB are removed. Limited maxillectomy and subtotal maxillectomy are included in this category. **(B)** Category II of maxillectomy defect in three-dimensional CT scan. ZMB and NMB are removed. Orbitomaxillectomy and orbitozygomaticomaxillectomy are included in this category. **(C)** Category III of maxillectomy defect in three-dimensional CT scan. All three buttresses are removed. Total maxillectomy and extended total maxillectomy are included in this category.

cartilage graft was used for buttress reconstruction. Occasionally, a free bone graft was additionally placed at the orbital floor in the patient, with preservation of the orbital contents. The rectus abdominis myocutaneous free flap combined with costal cartilage[5] was the most common composite autograft (seven patients) (Figure 3A), followed by the latissimus dorsi myocutaneous free flap combined with scapula (six patients), the scapular free flap combined with scapula (two patients) (Figure 3B), and the latissimus dorsi myocutaneous free flap combined with scapula and rib[6] (one patient) (Figure 3C) (Table 2).

RESULTS

Immediate reconstruction was carried out in 25 patients (66%) and secondary reconstruction in the remaining 13 patients (34%). The microsurgical

Table 1. Summary of categories of maxillectomy defects and buttress reconstruction.

		Reconstructed buttress						
Maxillary defect	No. of patients	ZMB	No.	PMB	No.	NMB	No.	None
Category I	6 (16%)	Not required		Scapula; lateral border; fibula	1 1	Scapula; lateral border	1	3
Category II	5 (13%)	Costal cartilage	1	Not required		—	0	4
Category III	27 (71%)	Scapula; medial border; costal cartilage; rib; titanium mesh	6 5 1 2	Scapula; lateral border	7	Scapula; medial border	1	12

**Six patients underwent reconstruction of two buttresses (ZMB and PMB), and one patient underwent reconstruction of three buttresses (ZMB, PMB, and NMB) in category III.*

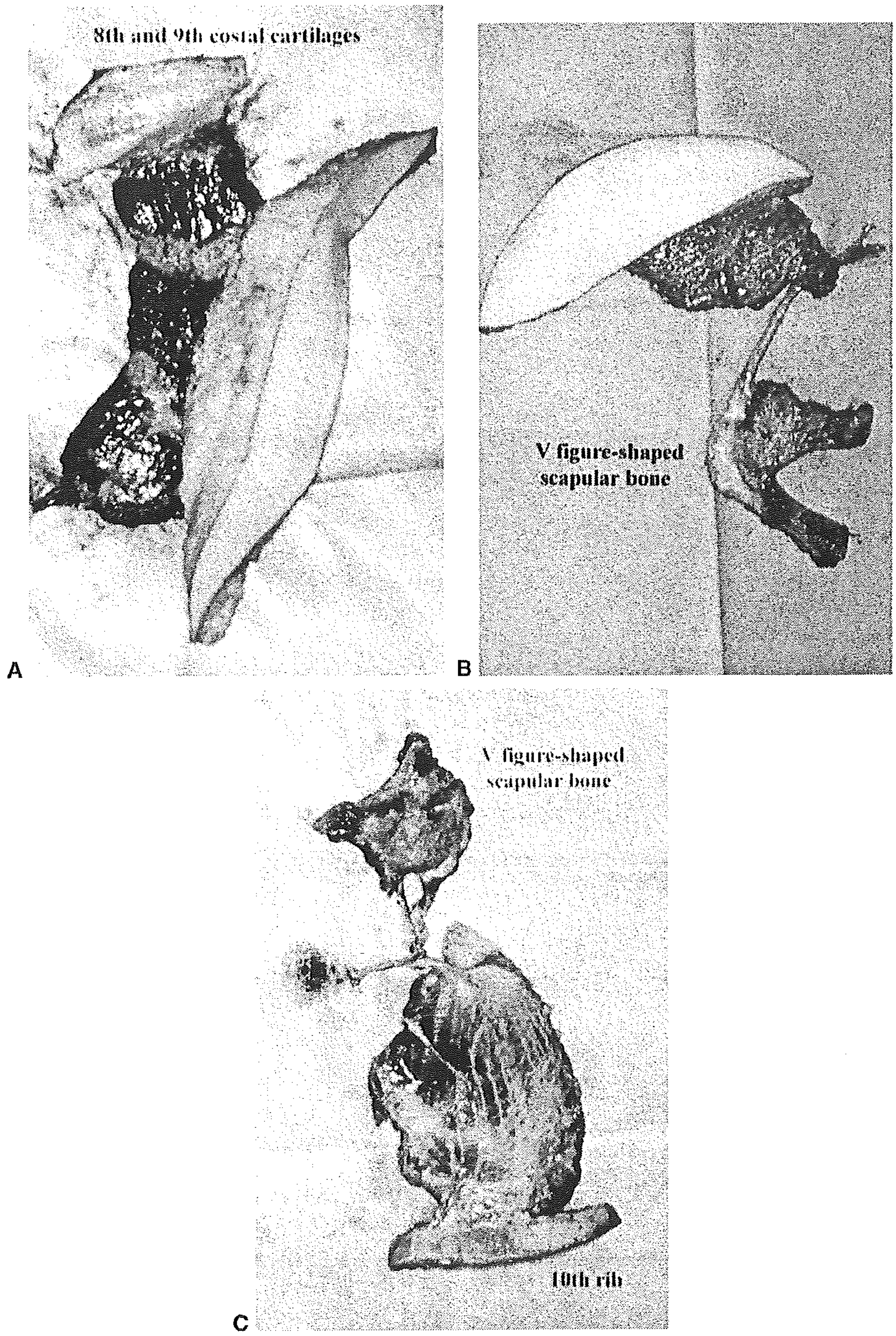


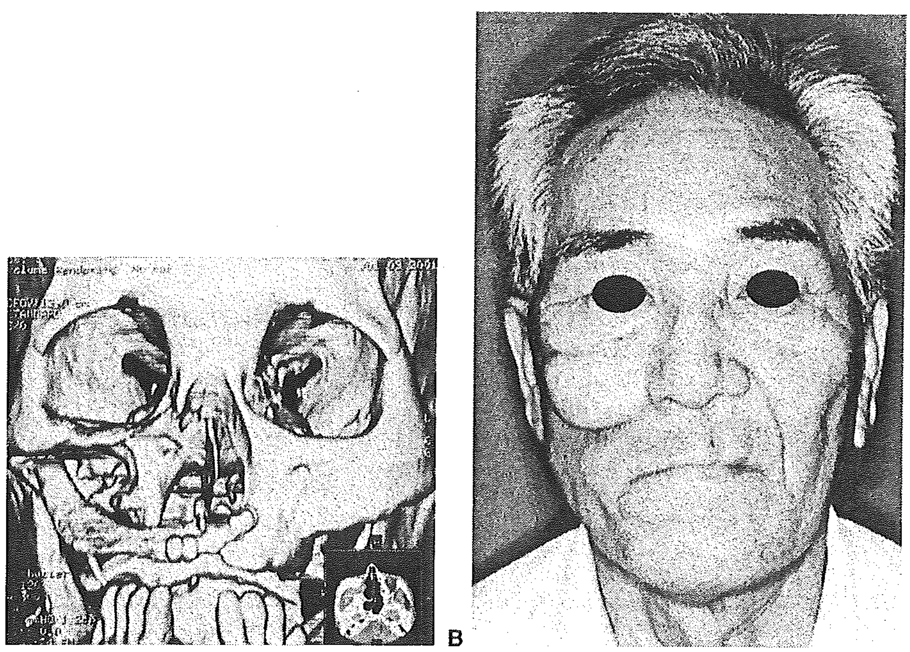
FIGURE 3. (A) The rectus abdominis myocutaneous free flap combined with costal cartilage. The vascular pedicle of this composite graft is the deep inferior epigastric vascular system, and the included eighth and ninth costal cartilages are supplied from the vascular connection between the eighth intercostal and deep epigastric vascular systems. **(B)** The latissimus dorsi myocutaneous flap combined with V-shaped scapular bone. The vascular pedicle of this composite graft is the thoracodorsal vascular system, and the included scapula is nourished by the angular branch. **(C)** The latissimus dorsi myocutaneous flap combined with V-shaped scapular bone and tenth rib. The vascular pedicle of this composite graft is the thoracodorsal vascular system. The scapula is nourished by the angular branch, and the included tenth rib is supplied from the communicating perforators from the latissimus branch of thoracodorsal to the tenth intercostal vascular system. The infraspinous fossa of the scapula was removed later, and the bony piece was used for reconstruction to the orbital floor.

Table 2. Reconstructive procedures in 38 patients with maxillectomy defect.

Reconstruction of soft tissue only	No. of patients	Reconstruction of skeletal and soft tissues	No. of patients
RAMFF	13	Vascularized composite autograft	
RFFF	2	RAMFF with CC	7
RFFF and TFF	1	LDMFF with S	6
TMF	1	SFF with S	2
TMF and TFF	1	LDMFF with S and R	1
MFF	1	OFFF	1
		Combination of titanium mesh	
		RAMFF	1
		SFF	1

Abbreviations: RAMFF, rectus abdominis myocutaneous free flap; RFFF, radial forearm free flap; TFF, temporoparietal fascial flap; TMF, temporalis muscle flap; MFF, median forehead flap; RAMFF with CC, rectus abdominis myocutaneous flap combined with costal cartilage; LDMFF with S, latissimus dorsi myocutaneous free flap combined with scapula; SFF with S, scapular free flap combined with scapula; LDMFF with S and R, latissimus dorsi myocutaneous free flap combined with scapula and rib; OFFF, osteocutaneous free flap of fibula; SFF, scapular free flap.
**RAMFF with CC failed in one patient.*

tissue transfer was used for 35 patients (92%). No flap failures were reported in the 34 patients with free flaps and three patients with pedicled flaps (97%). One rectus abdominis myocutaneous free flap combined with costal cartilage developed total necrosis because of arteriovenous thrombus 5 days postoperatively. In the patient, the palatal surface was covered with skin graft. In an average follow-up of 18 months (range, 4–108 months), even though four of 19 patients with buttress reconstruction received postoperative irradiation, no obvious absorption of the grafted bone and cartilage was noted in any of the patients. However, two patients had three-dimensionally contoured pieces of titanium mesh, and three patients had titanium plates and screws for fixing the grafted bone or cartilage at the reconstructed ZMB region that showed persistent cutaneous fistulas. The fistulas healed completely after the alloplastic materials were removed.



A B

FIGURE 4. The latissimus dorsi myocutaneous free flap combined with scapula for category I of maxillary defect. **(A)** The right PMB was reconstructed by lateral border of the scapula. **(B)** Postoperative appearance at 6 months. Palatal roof, lateral wall of nasal cavity, and buccal skin on the right side were replaced by the latissimus dorsi myocutaneous flap. Debulking of the flap is scheduled.

Reconstructed Buttresses. In category I maxillary defects, buttress reconstruction was carried out in three of six patients (50%). PMB was reconstructed with the scapula and fibula in two patients (Figure 4) and NMB with the scapula in one patient. The remaining three patients did not undergo buttress reconstruction. In category II maxillary defects, buttress reconstruction was carried out in one of five patients (20%). ZMB was reconstructed with costal cartilage in one patient. The remaining four patients did not undergo buttress reconstruction. In category III maxillary defects, buttress reconstruction was carried out in 15 of 27 patients (56%). ZMB was reconstructed in 14 patients. The medial border of the scapula was used for six patients and the costal cartilage for five patients (Figure 5), the rib for one patient, and titanium mesh for two patients. The PMB was reconstructed in six patients with the lateral border of the scapula. The NMB was reconstructed in one patient with the scapula. This series included six patients with reconstruction of two buttresses (ZMB and PMB) using aV-shaped scapula (Figure 6) and one patient with all three buttresses (ZMB, PMB, and NMB) using V-shaped scapulas and ribs (Figure 7). The remaining

A

B

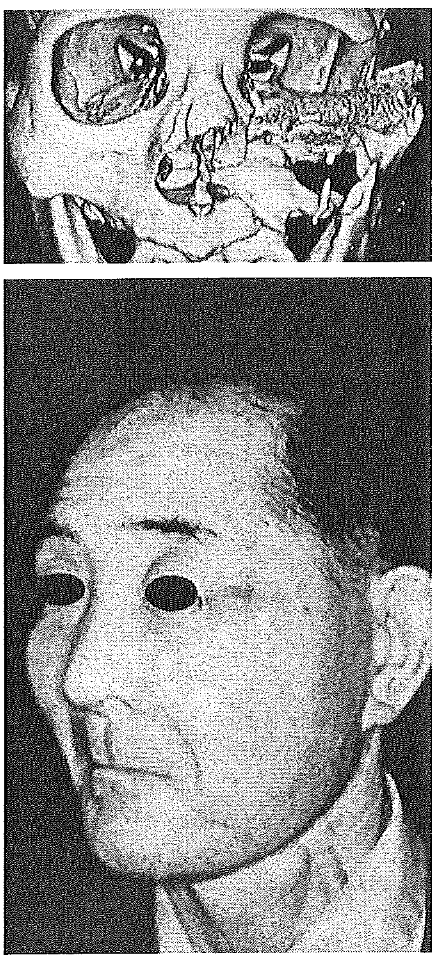


FIGURE 5. The rectus abdominis myocutaneous free flap combined with costal cartilage for category III maxillary defect. **(A)** The left ZMB was reconstructed by eighth and ninth costal cartilages. **(B)** Postoperative appearance at 8 months. Palatal roof, lateral wall of nasal cavity, and eye socket on the left side were replaced by the rectus abdominis myocutaneous flap.

A

B

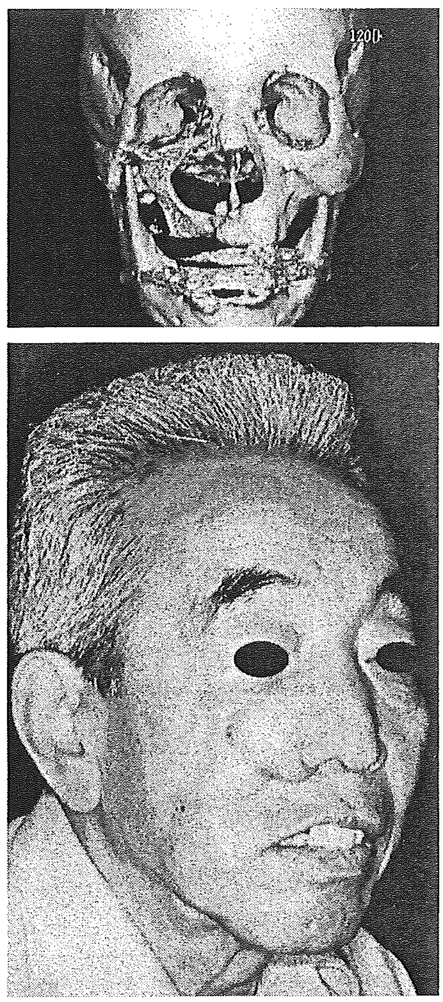


FIGURE 6. The latissimus dorsi myocutaneous free flap combined with V-shaped scapular bone for category III maxillary defect. **(A)** The right ZMB was reconstructed by the medial border of the scapula. The right PMB was reconstructed by the lateral border of the scapula. **(B)** Postoperative appearance at 25 months. Palatal roof, lateral wall of nasal cavity, and buccal skin on the right side were replaced by the latissimus dorsi myocutaneous flap.

12 patients did not undergo buttress reconstruction (see Table 1).

Functional and Aesthetic Outcomes. In category I and III maxillary defects (33 patients) in which the palate was included, the PMB was removed; 28 patients underwent palatal roof reconstruction with the transferred flap, and all of them had intelligible or better speech. The patients under-

A

B

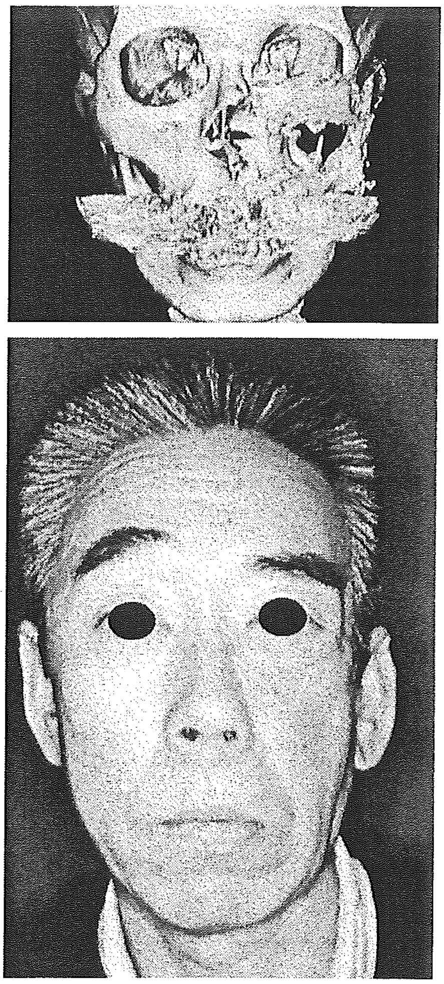


FIGURE 7. The latissimus dorsi myocutaneous free flap combined with V-shaped scapular bone and rib for category III maxillary defect. **(A)** The left ZMB was reconstructed by the tenth rib with one osteotomy. The left PMB was reconstructed by the lateral border of the scapula. The right NMB was reconstructed by the medial border of the scapula. **(B)** Postoperative appearance at 13 months. Palatal roof, lateral wall of nasal cavity, and buccal skin on the left side were replaced by the latissimus dorsi myocutaneous flap. Facial palsy caused by injury of facial nerve trunk and removal of buccal mimetic muscles on the left side was noted.

A

B

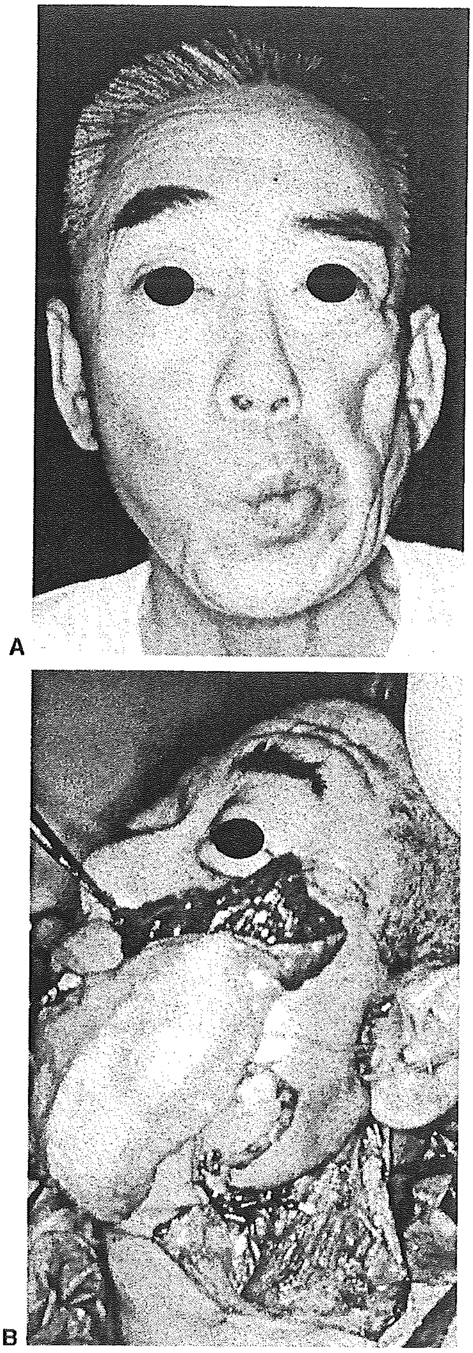


FIGURE 8. **(A)** The patient with asymmetry of buccal region caused by facial palsy and atrophy of muscular portion of the transferred flap at 32 months postoperatively. **(B)** Secondary surgical revision using deepithelized anterolateral thigh free flap combined with the reinnervated rectus femoris muscle flap was carried out. **(C)** Improved functional and aesthetic result was obtained (same patient as Figure 7).