ALTERNATIVE APPROACH USING THE COMBINED TECHNIQUE OF NERVE CROSSOVER AND CROSS-NERVE GRAFTING FOR REANIMATION OF FACIAL PALSY

YUHEI YAMAMOTO, M.D., Ph.D.,[1]* SATORU SASAKI, M.D.,[1]
MITSURU SEKIDO, M.D.,[1] TOICHIRO YOKOYAMA, M.D., Ph.D.,[1]
ARATA TSUTSUMIDA, M.D., Ph.D.,[1]
HIROSHI FURUKAWA, M.D., Ph.D.,[1]
YUTAKA SAWAMURA, M.D., Ph.D.,[2]
AND TSUNEKI SUGIHARA, M.D., Ph.D.[1]

An alternative approach, using a combination of nerve crossover and cross-nerve grafting technique in a single-stage procedure, was developed for the reconstruction of reversible facial palsy. This combined technique provides some benefits such as early facial reanimation resulting from the single-stage procedure, less morbidity and sufficient innervation with an application of the end-to-side anastomosis method, and efficient neural regeneration due to coaptation of the intratemporal facial nerve. Facial nerve rehabilitation, based on double innervation by hypoglossal and contralateral healthy facial nerves, takes advantage of reliable and physiological facial reanimation.

MICROSURGERY 23:251–256 2003

The value of nerve crossover and cross-face nerve grafting has become widely accepted for early facial reanimation following proximal facial nerve injury near the brain stem. These techniques to reanimate the paralyzed face are generally used when there is no considerable atrophy of the mimetic muscles within 12–24 months from the onset of facial palsy.

With the nerve crossover technique, rapid restoration of resting tone and powerful facial movements of the reinnervated face are obtained.[1,2] Currently, hypoglossal-facial nerve neurorrhaphy, with some modifications to reduce the damage to the hypoglossal nerve and avoid postoperative hemiglossal dysfunction, has become the most popular nerve crossover method.[3–7] On the other hand, with cross-face nerve grafting, coordinated facial motion is provided due to the use of the contralateral facial nerve as a motor source. This technique refers to an interpositional graft of the sural nerve placed between the facial nerve branches of the healthy side and corresponding facial nerve branches on the paralyzed side.[8,9] Recently, there have been some reports on the two-stage facial reanimation procedure, which is a combination of hypoglossal nerve crossover and cross-face nerve grafting to obtain more effective and physiological results.[10–12]

This article reports on an alternative approach for early facial reanimation, using a combination of nerve crossover and cross-nerve grafting techniques in a single-stage procedure.

CASE REPORT

A 68-year-old man underwent resection of an acoustic tumor, which resulted in a total facial palsy on the right side (Fig. 1). Facial nerve reconstruction, in combination with nerve crossover and cross-nerve grafting technique, was carried out 3 months after neurosurgery. This reanimation surgery was planned in a single-stage procedure with the cooperation of the plastic surgical and neurosurgical teams.

In the nerve crossover procedure, following a postauricular incision extended downward along the anterior margin of the sternocleidomastoid muscle and submandibular region, the mastoid process was partially resected to open the stylomastoid foramen. The descending portion of the facial nerve in the mastoid

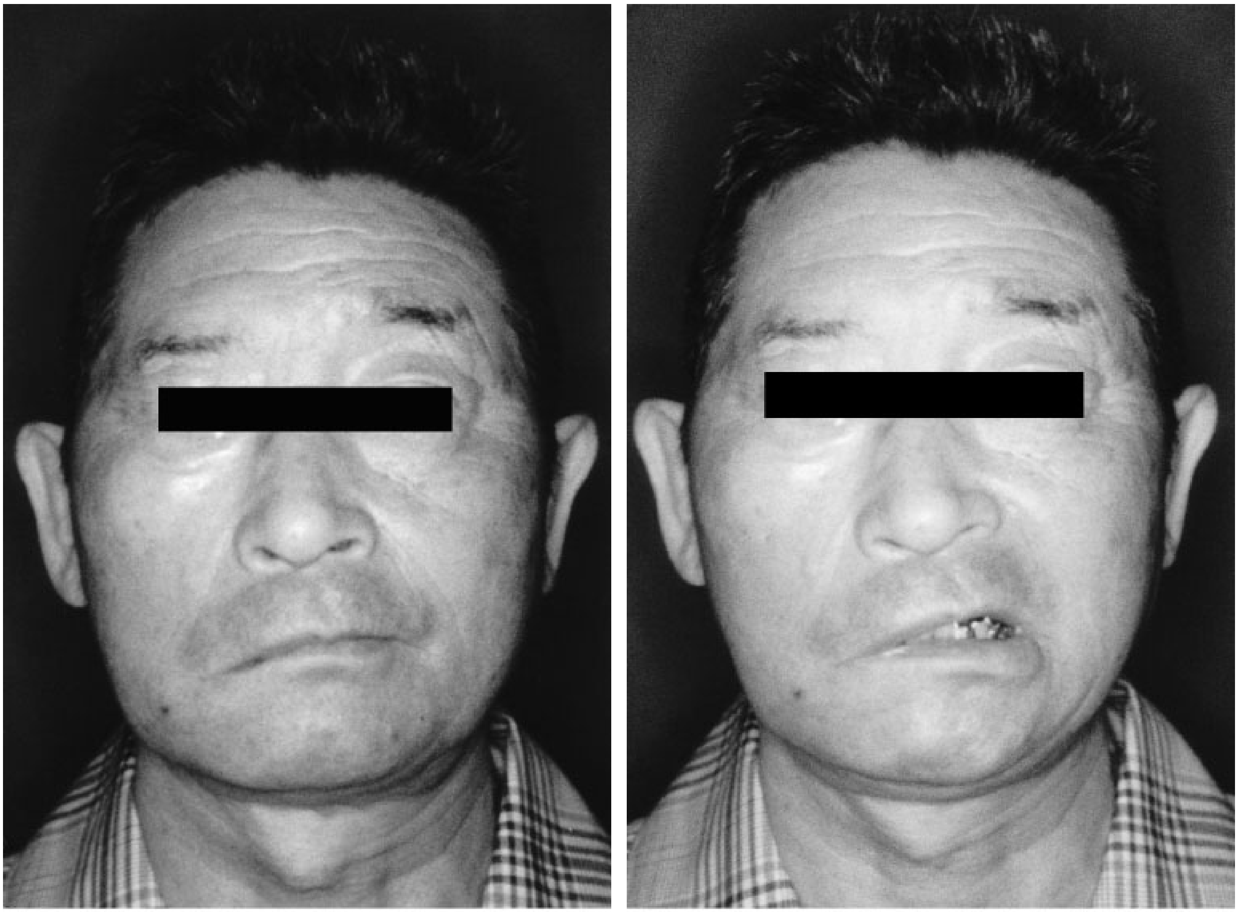
[1]Department of Plastic and Reconstructive Surgery, Graduate School of Hokkaido University, Sapporo, Japan

[2]Department of Neurosurgery, Graduate School of Hokkaido University, Sapporo, Japan

*Correspondence to: Yuhei Yamamoto, M.D., Ph.D., Department of Plastic and Reconstructive Surgery, Hokkaido University, Nishi 7 Kita 14 Kita-ku, Sapporo 060-8638, Japan. E-mail: yu-h1@med.hokudai.ac.jp

Received 23 January 2003; Accepted 18 March 2003

Published online in Wiley InterScience (www.interscience.wiley.com). DOI:10.1002/micr.10115



A B

*Figure 1. Preoperative appearance. **A:** At rest. **B:** Smiling.*

cavity, which was the "intratemporal facial nerve," was exposed over 3 cm in length and transected. The distal stump of the intratemporal facial nerve was mobilized down into the submandibular region. Then the hypoglossal nerve beneath the internal jugular vein was exposed, with retraction of the posterior belly of the digastric muscle to the inferoposterior direction. Under the operating microscope, 40–50% partial neurectomy was made on the lateral surface of the hypoglossal nerve, where the mobilized intratemporal facial nerve could be touched without any tension. Side-to-end neurorrhaphy was carried out between the neurectomy site of the hypoglossal nerve and the distal stump of the intratemporal facial nerve. Assisting sutures were also placed into the connective tissues surrounding these nerves, to further reduce tension on this neural tissue anastomosis.

In the cross-face nerve grafting procedure, two normal branches of the zygomatic and buccal plexus of the facial nerve were identified through two small skin incisions medial to the parotid gland on the normal side. A 28-cm-long sural nerve graft was tunneled across the upper lip and brought to the mandibular angle region. Then the epineural window on the paralyzed facial nerve trunk was created just lateral to the parotid gland by removal of the epineural sheath. End-to-side neurorrhaphy was carried out between the end of the nerve graft and the main trunk of the facial nerve through the epineural window. The other end of the nerve graft was divided into two fascicles and connected to the identified zygomatic and buccal branches of the healthy facial nerve without tension (Fig. 2).

The signs of mimetic muscle recovery started at 9 months after surgery, and facial reanimation progressively improved during the follow-up period. At postoperative month 13, an upper blepharoplasty was added on the palsy side at the patient's request. Currently, 22 months have passed; the patient has regained sufficient facial muscle tone and synchronous mimetic movement. At smiling, contraction of the reinnervated orbicularis oculi muscle was noted in the lateral canthal region. Also, the nasolabial fold at the reconstructed side was

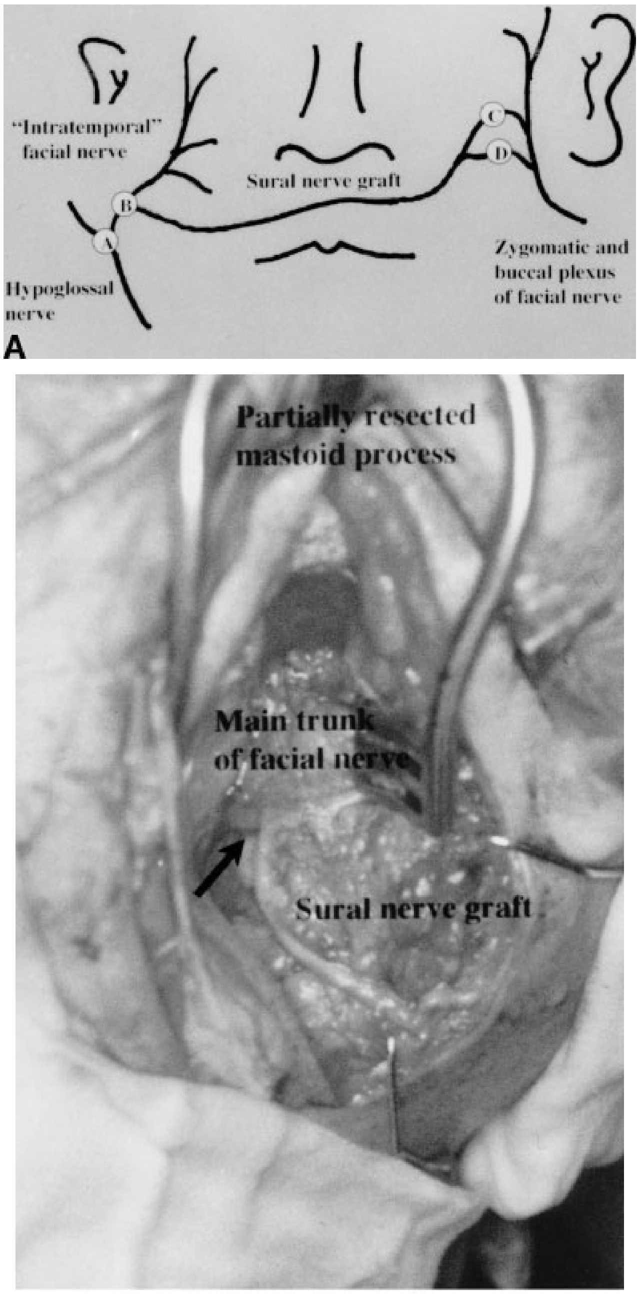


Figure 2. **A:** Schematic drawing of authors' approach, using a combination of nerve crossover and cross-nerve grafting techniques in single-stage procedure. Neurorrhapy A, side-to-end anastomosis between neurectomy site of hypoglossal nerve and distal stump of intratemporal facial nerve; neurorrhapy B, end-to-side anastomosis between end of sural nerve graft and main trunk of facial nerve through epineural window; neurorrhapy C and D, end-to-end anastomoses between two fascicles of nerve graft and zygomatic and buccal branches of healthy facial nerve. **B:** Intraoperative view of end-to-side anastomosis between end of sural nerve graft and main trunk of facial nerve through epineural window. Arrow indicates neurorrhapy site.

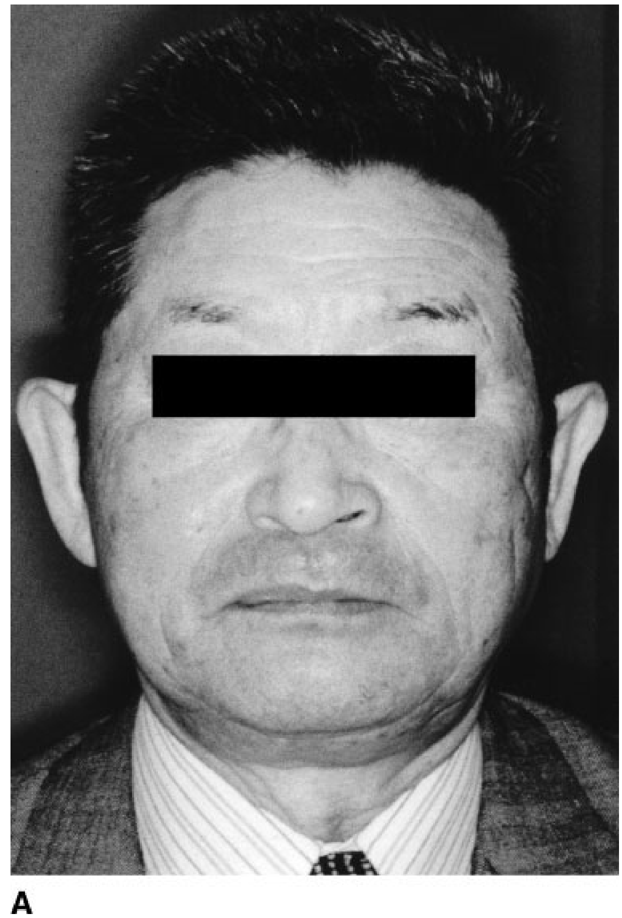


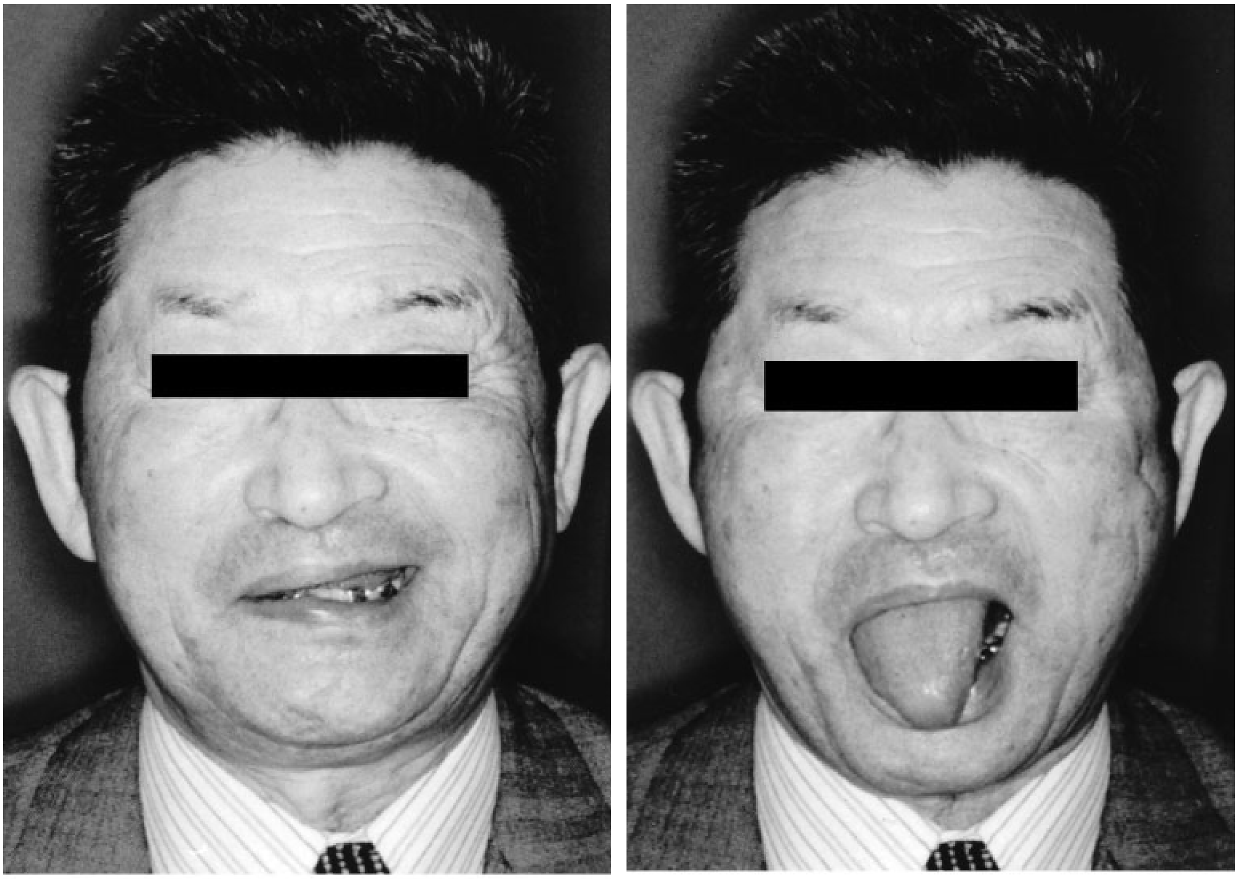
Figure 3.

furrowed by contraction of the reinnervated zygomatic major muscle. He exhibited almost complete restoration of facial symmetry, without hemiglossal dysfunction (Fig. 3).

Electroneuromyographic (ENMG) evaluation was performed 18 months after surgery. ENMG studies, with stimulation of the hypoglossal nerve on the paralyzed side and the facial nerve on the normal side, showed double innervation of the peripalpebral and perioral muscles on the operated side. Action potentials of these reinnervated mimetic muscles were noted by stimulation of the hypoglossal nerve and contralateral facial nerve through the cross-face nerve grafting (Fig. 4).

DISCUSSION

The hypoglossal nerve and the contralateral facial nerve are the most utilized motor donors in the treatment of reversible facial palsy when there is no atrophy of the facial mimetic muscles. Although the hypoglossal-facial nerve crossover technique provides reliable restoration



B C

Figure 3. Continued.
Figure 3. Appearance 20 months postoperatively. ***A:*** *At rest.* ***B:*** *Smiling.* ***C:*** *No clear evidence of tongue atrophy.*

of facial movement, this procedure leads to hemiglossal dysfunction, resulting in talking, chewing, and swallowing difficulties. To solve these problems, the hypoglossal-facial nerve side-to-end anastomosis method, involving approximately 40% partial neurectomy or removal of epi/perineurium of the hypoglossal nerve, has been developed.[3,5–7] In these techniques, some modifications such as interposing a nerve graft or mobilization of the distal part of the intratemporal facial nerve was necessary to obtain a tensionless anastomosis (Table 1). However, the nerve crossover method is associated with undesirable movement in the reanimated mimetic muscles. Therefore, the cross-face nerve grafting method, in which the contralateral healthy facial nerve provides a new source of innervation, is superior in terms of coordinated movement of the reinnervated face.

To obtain more physiological facial recovery, a combined technique with hypoglossal nerve crossover and cross-face nerve grafting has been introduced.[10–12] This technique is also aimed at preventing irreversible atrophic change of the paralyzed mimetic muscles during the long regeneration time of neural axons through cross-face nerve grafting. This combined technique was achieved in two stages in previous publications. The hypoglossal-facial nerve crossover and sural crossed facial nerve graft are carried out in the first stage. Eleven to 20 months later, in the second stage, distal ends of the cross-facial nerve graft are coapted with the peripheral branches of the facial nerve on the paralyzed side (see Table 1).

The authors' approach, using the combined technique of nerve crossover and cross-nerve grafting, involved some modifications compared to previous reports. First, the present technique was carried out in a single-stage procedure. The main disadvantages of the two-stage procedure are the delay between stages and the burden on patients undergoing multiple surgeries. In 1994, Inigo et al. demonstrated favorable results of recovery of facial palsy in patients undergoing single-stage cross-facial nerve grafting less than 1 year after the onset of facial palsy.[13] Although there is controversy in the single-stage achievement of cross-facial nerve grafting, there is no distinct reason to avoid the single-stage

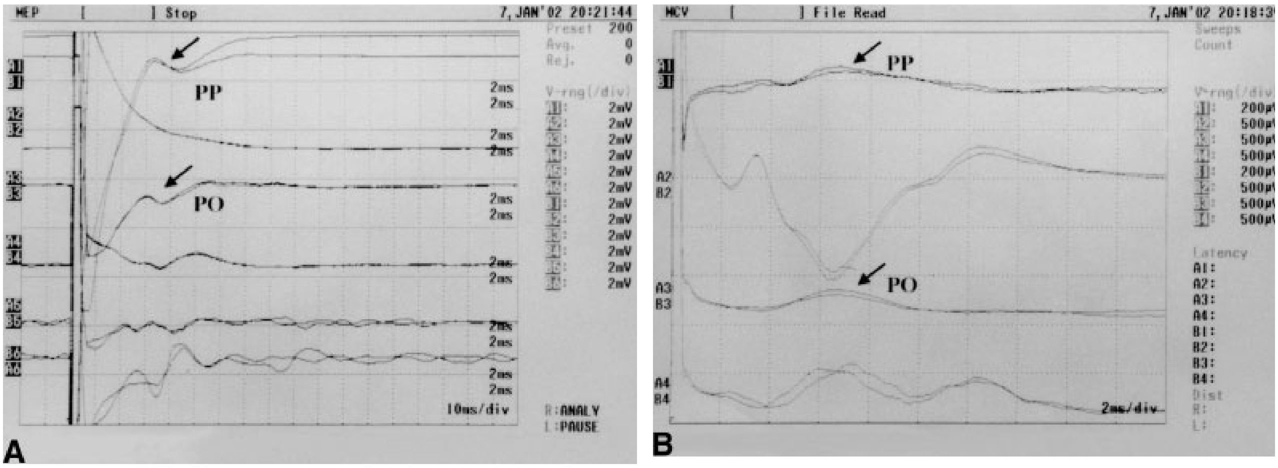


*Figure 4. Electroneuromyographic findings, 18 months after surgery. **A:** After stimulation of hypoglossal nerve on paralyzed side. Arrows indicate action potentials obtained from peripalpebral (PP) and perioral (PO) muscles on operated side. **B:** After stimulation of facial nerve on normal side. Arrows indicate action potentials obtained from peripalpebral (PP) and perioral (PO) muscles on operated side.*

Table 1. Recent Innovations in Reanimation Techniques for Reversible Facial Palsy*

Nerve crossover technique			
HGN-FN with interposition of nerve graft			
Side-to-end neurorrhaphy through partial neurectomy of HGN	May et al.	Otolaryngology	Reference 3
HGN-intratemporal FN			
Side-to-end neurorrhaphy through partial neurectomy of HGN	Sawamura and Abe	Neurosurgery	Reference 5
	Atlas and Lowinger	Otolaryngology	Reference 6
Side-to-end neurorrhaphy through epineural window of HGN	Koh et al.	Plastic surgery and neurosurgery	Reference 7
Combination of nerve crossover and cross-nerve grafting			
Two-stage procedure			
HGN-FN with division of branches, if necessary			
End-to-end neurorrhaphy	Endo et al.	Plastic surgery	Reference 11
Side-to-end neurorrhaphy through partial neurectomy of HGN	Mersa et al.	Plastic surgery	Reference 10
Side-to-end neurorrhaphy through perineural window of HGN and SNG-branches of paralyzed FN	Yoleri et al.	Plastic surgery	Reference 12
End-to-end neurorrhaphy			
Single-stage procedure			
HGN-intratemporal FN			
Side-to-end neurorrhaphy through partial neurectomy of HGN and SNG-trunk of paralyzed FN			
End-to-side neurorrhaphy through epineural window of FN	Present authors	Plastic surgery and neurosurgery	

HGN, hypoglossal nerve; FN, facial nerve; SNG, sural nerve graft.

procedure for early facial reanimation, especially in combination with the nerve crossover technique. Second, end-to-side neurorrhaphy was applied to create neural communications both between the distal stump of the facial trunk and the hypoglossal nerve, and between the end of the sural nerve graft and the main trunk of the paralyzed facial nerve. In the hypoglossal-facial nerve crossover, to prevent hemiglossal dysfunction, an anastomosis was performed on the partial neurectomy site of the hypoglossal nerve. In the cross-face nerve grafting, to preserve the whole continuity of the facial nerve plexus on the paralyzed side, an anastomosis was performed through the epineural window created by removal of the epineural sheath of the facial trunk. Regeneration of end-to-side nerve repair through the epineural window was proved by previous experimental and clinical studies.[7,14] The use of end-to-side neurorrhaphy in these studies not only decreased possible functional damage to the continuity of the hypoglossal and restored facial nerves, but also provided sufficient reinnervation of the facial nerve, based on clinical results and the findings of ENMG examinations.

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.

REFERENCES

1. Conley J, Baker DC. Hypoglossal-facial nerve anastomosis for reinnervation of the paralyzed face. Plast Reconstr Surg 1979;63:63–72.
2. Stennert E. Hypoglossal facial anastomosis: its significance for modern facial surgery. Clin Plast Surg 1979;6:471–486.
3. May M, Sobol SM, Mester SJ. Hypoglossal-facial nerve interpositional-jump graft for facial reanimation without tongue atrophy. Otolaryngol Head Neck Surg 1991;104:818–825.
4. Arai H, Sato K, Yanai A. Hemihypoglossal-facial nerve anastomosis in treating unilateral facial palsy after acoustic neurinoma resection. J Neurosurg 1995;82:51–54.
5. Sawamura Y, Abe H. Hypoglossal-facial nerve side-to-end anastomosis for preservation of hypoglossal function: results of delayed treatment with a new technique. J Neurosurg 1997;86:203–206.
6. Atlas MD, Lowinger DSG. A new technique for hypoglossal-facial nerve repair. Laryngoscope 1997;107:984–991.
7. Koh KS, Kim J, Kim CJ, Kwun BD, Kim S. Hypoglossal-facial crossover in facial-nerve palsy: pure end-to-side anastomosis technique. Br J Plast Surg 2002;55:25–31.
8. Scaramella LF. Anastomosis between the two facial nerves. Laryngoscope 1975;85:1359–1366.
9. Anderl H. Cross-face nerve transplant. Clin Plast Surg 1979;6:433–449.
10. Mersa B, Tiangco DA, Terzis JK. Efficacy of the "baby-sitter" procedure after prolonged denervation. J Reconstr Surg 2000;16:27–35.
11. Endo T, Hata J, Nakayama Y. Variations on the "baby-sitter" procedure for reconstruction of facial paralysis. J Reconstr Surg 2000;16:37–43.
12. Yoleri L, Songur E, Mavioglu H, Yoleri O. Cross-facial nerve grafting as an adjunct to hypoglossal-facial nerve crossover in reanimation of early facial paralysis: clinical and electrophysiological evaluaion. Ann Plast Surg 2001;46:301–307.
13. Inigo F, Ysunza A, Rojo P, Trigos I. Recovery of facial palsy after crossed facial nerve grafts. Br J Plast Surg 1994;47:312–317.
14. Viterbo F, Trindade JC, Hoshino K, Mazzoni A. Two end-to-side neurorrhaphies and nerve graft with removal of the epineural sheath: experimental study in rats. Br J Plast Surg 1994;47:75–80.