Differential Reanimation of the Midface and Lower Face Using the Masseteric and Hypoglossal Nerves for Facial Paralysis

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BACKGROUND: Hypoglossal nerve transfer is frequently employed to reanimate the paralyzed facial muscles after irreversible proximal facial nerve injury. However, it can cause significant postoperative synkinesis because it involves the reinnervation of the whole mimetic musculature using a single motor source.

OBJECTIVE: To describe our experience with differential reanimation of the midface and lower face using separate motor sources in patients with short-term facial paralysis after brain surgery.

METHODS: Seven patients underwent combined nerve transfer (the masseteric nerve to the zygomatic branch and the hypoglossal nerve to the cervicofacial division of the facial nerve) and cross-facial nerve grafting with the aim of achieving a spontaneous smile. The median duration of paralysis before surgery was 7 mo and follow-up ranged from 7 to 31 mo (mean: 18 mo). For evaluation, both physical examination and video analysis were performed.

RESULTS: In all patients, reanimation of both the midface and the lower face was successful. A nearly symmetrical resting lip was achieved in all patients, and they were able to voluntarily elevate the corners of their mouths without visible synkinesis and to close their eyes while biting. No patient experienced impairment of masticatory function or tongue atrophy.

CONCLUSION: Differential reanimation of the midface and lower face with the masseteric and hypoglossal nerves is an alternative method that helps to minimize synkinetic mass movement and morbidity at the donor site.

KEY WORDS: Facial paralysis, Facial reanimation, Hypoglossal nerve, Masseteric nerve, Nerve transfer

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When proximal injury to the facial nerve results from an intracranial event and the proximal stump of the nerve is not accessible for grafting, neurotization of the distal facial nerve is considered to be an appropriate strategy. While the hypoglossal nerve has been the most common motor nerve employed in patients with short-term facial paralysis[1-4] since the first such procedure was reported by Körte in 1904,[5] the masseteric nerve has been used as an alternative motor source[6-12] since 1978.[13] However, nerve transfers from a single motor source can lead to significant postoperative synkinesis, which is sometimes bothersome for patients, due to reinnervation of the whole mimetic musculature via a single motor source.[14-16] The purpose of this article is to present a modified nerve transfer technique for short-term facial paralysis, which involves differential reanimation of the midface and lower face with the masseteric and hypoglossal nerves, respectively.

ABBREVIATIONS: FNGS2.0, facial nerve grading System 2.0

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METHODS

This study was performed according to the institutional ethical guidelines. The patients in the figures and videos consented to publication of their images.

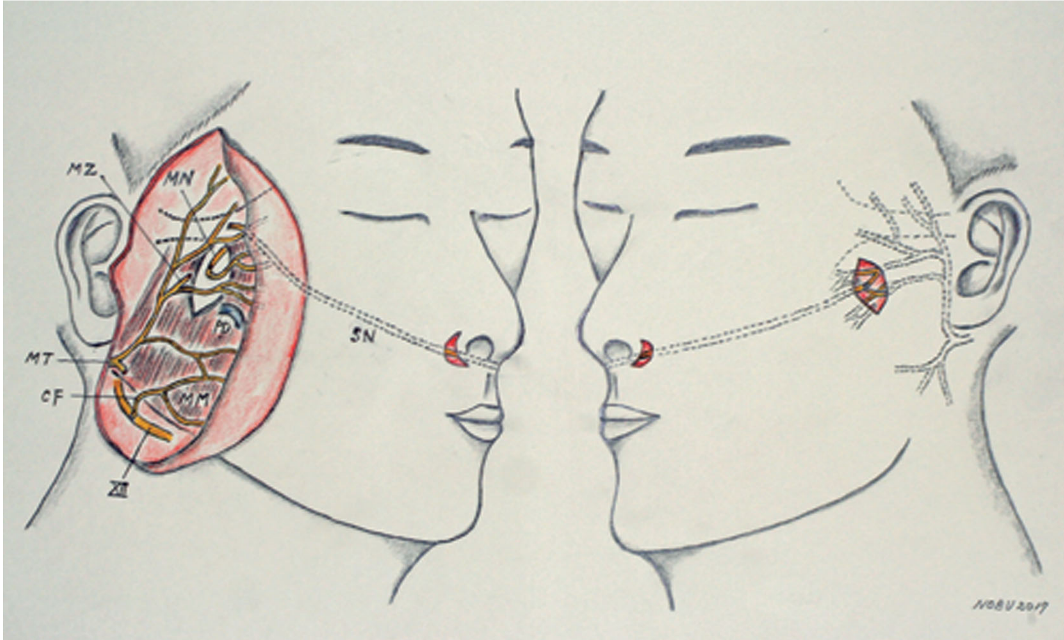

FIGURE 1. *Schematic drawing of the procedure. Small bilateral incisions are made in the alar–cheek junction to assist with the passing of the nerve graft across the midline of the face. SN, sural nerve graft; MN, masseteric nerve; MZ, main zygomatic branch; MM, masseter muscle; PD, parotid duct; MT, main trunk of the facial nerve; CF, cervicofacial division of the facial nerve; XII, hypoglossal nerve.*

Between May 2013 and August 2016, 7 consecutive patients aged from 14 to 67 yr (mean age: 46 yr) underwent combined nerve transfer. The masseteric nerve was transferred to the main zygomatic branch of the facial nerve, and the hypoglossal nerve was transferred to the cervicofacial trunk of the facial nerve in combination with cross-facial nerve grafting, with the aim of achieving a spontaneous smile. Staged cross-facial nerve grafting was performed between the bilateral zygomatic branches of the facial nerve, and secondary neurorrhaphy was carried out on the affected side after confirming that the Tinel sign reached the affected side. In all of the patients, facial paralysis had developed after resection of a brain tumor. Nerve transfer was performed if the patient showed no clinical or electrical evidence of facial nerve function at 6 mo after injury, or was done as soon as possible if facial nerve transection had occurred during the original brain surgery. The median interval from the onset of facial paralysis to nerve transfer was 7 mo.

Surgical Technique

Figure 1 shows a diagram of the procedure. Initially, a preauricular skin incision is made on the affected side, and then it is extended to the inframandibular region. Next, a skin flap is raised above the fascia of the parotid gland and this flap is extended to the anterior border of the gland. The superficial temporal vein, which empties into the retromandibular vein, is employed as a landmark for the temporofacial division of the facial nerve. After the temporofacial division, which generally lies on the retromandibular vein, has been identified, the main facial nerve trunk is exposed by retrograde dissection, and then the cervicofacial division is identified through antegrade dissection. The intraparotid zygomatic branches running across the masseter muscle are exposed to allow subsequent neurorrhaphy to the masseteric nerve.

The masseteric nerve is identified after bluntly dividing the masseter muscle fibers at the area bounded by the inferior margin of the zygomatic arch and the mandibular notch. This area provides a palpable landmark for the masseteric nerve, which always courses anteroinferiorly over the deep part of masseter. The masseteric nerve is dissected distally until an adequate length has been obtained, after which it is severed and transposed superficially. At this level, the masseteric nerve generally has 1 to 2 fascicles and is attached end-to-end to the main zygomatic branch of the facial nerve using 10/0 nylon epineural sutures under an operating microscope. The main zygomatic branch, which never travels upward beyond the zygomatic arch, is selected to avoid postoperative synkinetic eye movement.

The hypoglossal nerve is identified after retracting the posterior belly of the digastric muscle behind the mandibular angle, and less than 40% of the cross-sectional area of the nerve is severed. The cervicofacial division of the facial nerve is cut and mobilized, and direct end-to-side coaptation is carried out at the neurectomy site of the hypoglossal nerve with 10/0 nylon epineural sutures under an operating microscope. Otherwise, a short sural nerve graft is used to connect the cervicofacial division of the facial nerve and the partially neurectomized hypoglossal nerve. The cervicofacial division of the facial nerve generally contains a buccal branch or at least 1 branch communicating with the buccal branches of the facial nerve.

On the healthy side of the face, a 20-mm linear incision is made approximately 1 cm below the inferior border of the zygomatic arch at the level of the proximal end of the arch to identify the zygomatic branches of the facial nerve that are involved in smiling movements. Several zygomatic and buccal branches of the facial nerve, as well as the parotid duct, can be exposed through this incision. One or 2 zygomatic

TABLE 1. Summary of Patient Data

Case	Age/sex	Etiology	Duration of palsy (mo)	Additional procedures	FNGS2.0 (pre/post)	Follow-up after secondary neurorrhaphy (mo)
1	64/F	BT	7	BL, LL, HLS	VI/IV	31
2	67/F	BT	4	BL, LL, HLS	VI/III	25
3	14/M	BC	27	No	VI/IV	20
4	49/F	BT	9	BL, HLS	VI/IV	19
5	42/F	BT	9	BL, LL	VI/III	16
6	32/M	BT	7	No	VI/III	10
7	53/M	BT	7	HLS	VI/III	7

FNGS2.0, facial nerve grading scale 2.0; BT, brain tumor; BC, brain cavernoma; BL, brow lift; LL, levator lengthening; HLS, horizontal lower lid shortening.

branches are selected as donor nerves (those moving the corners of the mouth while causing minimal coordinated contraction of orbicularis oculi during electrostimulation). The selected branches often follow the course of the transverse facial artery. It is very important to preserve at least 1 adjacent synergic branch to avoid impairment of facial muscle function on the healthy side.

For cross-facial nerve grafting, a sural nerve graft measuring approximately 30 cm is harvested from the leg. Cross-facial grafting is done after creating a skin tunnel between the 2 cheeks. The direction of the sural nerve graft is reversed and then it is passed through the tunnel, followed by end-to-end microcoaptation between the selected zygomatic branches and the nerve graft on the healthy side with 10/0 nylon epineural sutures. After closing the parotid gland with absorbable sutures, the other end of the sural nerve graft is left intact in the subcutaneous pocket in front of the auricle on the affected side.

The second stage of the procedure, connecting the distal end of the nerve graft to the selected peripheral zygomatic branch of the facial nerve, is performed at 6 to 8 mo after Tinel's sign has been detected at the distal end of the cross-facial nerve graft. In this procedure, which is performed via the same incision, the masseteric-zygomatic branch neurorrhaphy created during the first stage of the operation remains undisturbed. The peripheral zygomatic branches, which are located anterior to the parotid gland, are dissected, and 1 of the branches that moves the corners of the mouth during electrostimulation is selected for neurorrhaphy. Additional surgical procedures, including brow lifting, horizontal lower lid shortening, and upper lid levator lengthening, are carried out if necessary.

RESULTS

The results are listed in Table 1. The mean postoperative follow-up period was 18 mo (range: 7-31 mo). Preoperative and postoperative paralysis was evaluated according to the Facial Nerve Grading System 2.0 (FNGS2.0)[17] using videos. All patients were classified as grade VI (no facial movement) preoperatively, although 2 patients exhibited partial muscle tone and the others had flaccid facial paralysis. Movement of the cheek while biting was initially observed at 3 to 5 mo after the first-stage procedure. After the second-stage procedure, all patients achieved a nearly symmetrical resting lip appearance and were able to voluntarily elevate the corners of their mouths without synkinesis (Figure 2). The postoperative facial function score was grade III in 4 patients and grade IV in 3 patients. In addition, all of the patients were able to close their eyes while biting. None of the patients are able to smile spontaneously and effortlessly. However, none of them have impairment of mastication or tongue function and none of them have visible atrophy of masseter or the tongue (see **Videos, Supplemental Digital Content 1 and 2**, which demonstrate preoperative and postoperative facial movement in cases 2 and 6).

DISCUSSION

Nerve transfer is indicated when the main trunk of the facial nerve has been damaged and is unavailable for grafting, while the distal branches and mimetic muscles are still viable. Among the available nerve transfer procedures, the most frequent is hypoglossal-facial nerve anastomosis,[1,3] with or without addition of cross-facial nerve grafting, and this has been the case since Korte and Bernhardt first described the hypoglossal nerve transfer procedure in 1903.[5] The method of hypoglossal-facial nerve anastomosis has been modified to improve results and reduce morbidity at the donor site.[2,4,18] On the other hand, using the masseteric nerve for facial reanimation was initially reported by Spira in 1978.[13] Subsequently, several articles have been published describing the advantages of employing the masseteric nerve for nerve transfer surgery.[6-12] It has also been demonstrated that severing the masseteric nerve results in minimal donor-site morbidity.[19]

In general, facial reanimation surgery aims to restore resting symmetry, along with oral competence, eye closure, voluntary facial movement, and effortless spontaneous expression in the absence of synkinesis, while causing minimal loss of function due to harvesting of donor motor nerves. Although both the hypoglossal and masseteric nerves are powerful motor sources, using a single motor source can easily lead to postoperative mass movement.[14-16] Such synkinetic mass movements sometimes annoy patients and hamper their social interactions.

Although the hypoglossal and masseteric nerves are useful motor sources associated with minimal donor-site morbidity, there are differences between these 2 nerves. First, the hypoglossal

FIGURE 2. *Case 2. Preoperative status at rest* **A**, *upon closure of the eye* **B**, *and during voluntary smiling* **C**. *One year after the surgical treatment, which included brow lifting and upper lid levator lengthening. The patient's status at rest* **D**, *upon closure of the eye* **E**, *and during voluntary smiling* **F**.

nerve is better at preserving the resting tone of the innervated mimetic muscles than the masseteric nerve. Second, the hypoglossal nerve is located close to the main trunk and the cervicofacial division of the facial nerve, whereas the masseteric nerve is located close to the zygomatic branch and temporofacial division of the facial nerve.

The author originally employed masseteric nerve transfer to the temporofacial division of the facial nerve for the treatment of facial paralysis.[11] However, in some patients, this procedure resulted in a lack of reanimation of the lower facial region and synkinetic oral and eye movements. Therefore, the author modified the original nerve transfer technique based on the idea that using appropriate combinations of the masseteric and hypoglossal nerves to reanimate different regions of the face might make it possible to decrease synkinetic mass movement. Since 2013, the author has utilized 2 different motor sources, the masseteric and hypoglossal nerves, instead of a single motor source to decrease synkinetic mass movement when reanimating the lower facial region. The masseteric nerve is transferred to the zygomatic branch of the facial nerve to make it possible for the patient to elevate the corners of their mouth voluntarily, and the hypoglossal nerve is transferred to the cervicofacial division of the facial nerve to acquire resting lip symmetry as well as symmetry during lip movement. A short nerve graft is sometimes required during hypoglossal–cervicofacial division neurorrhaphy because the buccal branches connecting to the cervicofacial division should be preserved to innervate the buccal region. Since the number of our patients is small and the follow-up periods of some patients are relatively short, it might be early to decide this technique is superior to the other single nerve transfer in mass movement. So far, the results are satisfactory with regard to resting lip symmetry, voluntary cheek and lip movement, and synkinetic mass movement.

Since there is no universal grading system for evaluating patients' postoperative facial appearances after facial reanimation surgery, it is difficult to compare our results with those obtained using other procedures. Our patients exhibited grade III function at best according to the FNGS2.0 because of the lack of reanimation of the upper facial region. Although the lack of reanimation of the upper facial region is a drawback of our procedure, eye closing can be achieved via lower orbicularis oculi muscle contraction during teeth clenching. Of course, additional brow lifting and upper lid levator lengthening are necessary if the patient has flaccid facial paralysis combined with upper lid retraction, as was seen in our cases.

The main disadvantage of reanimating the facial muscles by using motor nerves other than the facial nerve is the potential for dissociation of facial movements and lack of spontaneity. It is interesting that effortless spontaneous smiling as a result of cerebral adaptation has been reported by several authors after the masseteric nerve was employed for reanimation.[8,9,20,21] Therefore, the masseteric nerve is transferred to the zygomatic branch in this modified technique due to the expectation that cerebral adaptation will occur as well as its proximity to the zygomatic branch. Another approach to achieving a spontaneous smile is cross-facial nerve grafting between the zygomatic branches, which is also employed in our method.[9,12] It remains unclear whether it is possible to acquire a spontaneous and effortless smile using this modified nerve transfer technique, and strict physiotherapy or further technical refinement might be required to acquire an effortless spontaneous smile. Also, functional free muscle transfer using the cross-facial nerve graft as the motor signal instead of secondary neurorrhaphy between the cross-facial graft and peripheral zygomatic branches could be a solution in our patients if the effectiveness of cross-face nerve grafting is not sufficient after long-term follow-up. Nonetheless, differential reanimation of separate regions of the face using two nerves is an alternative to using a single motor source to reanimate a paralyzed hemiface, and this approach minimizes synkinetic mass movement.

CONCLUSION

Differential reanimation of the midface and lower face with the masseteric and hypoglossal nerves provides a nearly symmetrical resting lip and restores voluntary cheek and lip movement while minimizing synkinetic mass movement after short-term facial paralysis. Moreover, it results in minimal donor-site morbidity.

Disclosure

The author has no personal, financial, or institutional interest in any of the drugs, materials, or devices described in this article.

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COMMENT

This is a nice technique for minimizing synkinesis, with good reanimation results. Their method does appear to decrease synkinesis but does not eliminate it.

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