ARTICLE IN PRESS
+ MODEL
Journal of Plastic, Reconstructive & Aesthetic Surgery (2015) xx, 1–7

JPRAS
An International Journal of Surgical Reconstruction
www.JPRASurg.com

Masseteric nerve transfer for short-term facial paralysis following skull base surgery☆

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Received 24 September 2014; accepted 27 February 2015

KEYWORDS
Facial nerve;
Facial paralysis;
Facial reanimation;
Masseteric nerve;
Nerve transfer

Summary *Background:* Nerve transfers have been widely used to reanimate paralyzed facial muscles after irreversible proximal injuries to the facial nerve. The author has developed a technique involving masseteric nerve transfer combined with cross-facial nerve grafting for treating skull base surgery-induced facial paralysis. This paper aims to demonstrate that this procedure is effective and causes negligible donor site morbidity.
Methods: Seven patients who developed facial paralysis after the removal of skull base tumors were treated with masseteric nerve transfer combined with cross-facial nerve grafting with the aim of reanimating the midface. The mean period of preoperative paralysis was 6 months. The follow-up period ranged from 22 to 65 months (mean: 46 months). The patients were evaluated with physical examinations and video analysis.
Results: Successful reanimation of the midface was achieved in all patients except one, whose muscle tone recovered. On average, facial motion developed 4 months after the nerve transfer. Only minimal coordinated eyelid movement was seen during biting. None of the patients experienced impaired masticatory function or visible wasting of the masseter muscle. All of the patients who recovered the ability to contract their paralyzed muscles were able to close their eyes tightly during biting; however, none of the patients have been able to achieve an effortless spontaneous smile.
Conclusions: Masseteric nerve transfer is an alternative method for selective reanimation of the midface and does not cause donor site morbidity.

☆ Part of this study was presented at the 23rd Annual Meeting of the North American Skull Base Society at The Doral, Miami, 15–17 February 2013.
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http://dx.doi.org/10.1016/j.bjps.2015.02.031
1748-6815/

Introduction

When the facial nerve suffers a proximal injury during skull base surgery and the proximal stump of the facial nerve is not available for grafting, neurotization of the distal facial nerve is an appropriate treatment strategy. Several donor nerves are available for reanimating the face in such cases,[1,2] although the hypoglossal nerve is the most commonly used motor source.[3–6] As is the case for procedures involving other donor nerves, using the hypoglossal nerve to reanimate the face can result in various degrees of donor site morbidity.[5,6]

The use of the masseteric nerve, which innervates the masseter muscle, for facial reanimation was first described by Spira in 1978.[7] The masseteric nerve has since become the standard motor source for free muscle transplantations for bilateral congenital facial paralysis (MÖbius syndrome).[8–11] Moreover, it has been used as an alternative motor source for nerve transfers to the facial nerve during the treatment of short-term facial paralysis, and various other surgical procedures involving the use of the masseteric nerve have been reported.[12–17] The purpose of this study was to describe the author's facial reanimation strategy for patients with short-term facial paralysis, which involves using the masseteric nerve, together with its advantages and disadvantages.

Patients and methods

Between March 2009 and October 2012, 7 consecutive patients (all female) with ages ranging from 50 to 63 years (mean age: 57 years) were treated with masseteric nerve transfers to the upper trunk (temporofacial division) of the facial nerve combined with cross-facial nerve grafting, resulting in the dual innervation of their paralyzed muscles. The cross-facial nerve grafting between the bilateral zygomatic branches of the facial nerve was performed as a one-stage procedure. All of the patients had developed facial paralysis after the extirpation of a skull base tumor. Surgery was performed if there was no clinical or electrical evidence of facial nerve function at 6 months after the injury or as soon as possible if the facial nerve had been transected during a previous surgical procedure. The mean time between the onset of facial paralysis and the nerve transfer was 6 months.

Surgical technique

A preauricular skin incision was made on the affected side of the face, and a skin flap was elevated above the parotid fascia and extended to the anterior border of the gland (Figure 1). The retromandibular vein was used as a landmark to identify the upper trunk of the facial nerve.[18] After identifying the upper trunk of the facial nerve, the zygomatic and buccal branches were followed peripherally across the masseter muscle.

The masseteric nerve arises from the mandibular division of the trigeminal nerve and leaves the infratemporal fossa through the mandibular notch. It then passes into the masseter muscle from the muscle's medial surface via the space that is formed by the inferior border of the zygomatic arch superiorly and the mandibular notch inferiorly. Next, the nerve generally courses anteroinferiorly along the deep part of the masseter muscle. Therefore, the area that is formed by the inferior border of the zygomatic arch and the mandibular notch can be used as a palpable landmark for identifying the masseteric nerve.

Figure 1 Operative marking for the masseteric nerve transfer. X, which is the center of the area surrounded by the zygomatic arch above and mandibular notch below, indicates the point where the masseteric nerve was exposed. The zygomatic major muscle (red), parotid duct, and anterior margin of the masseter muscle are also indicated.

After dividing the masseteric fascia, the masseter muscle was bluntly divided along its fibers towards the deep part of the muscle. Dividing the muscle in the region between the zygomatic arch and mandibular notch exposes the section of the masseteric nerve running across the deep part of the muscle. Next, the nerve was dissected distally, and once an adequate length had been obtained, it was transected and transposed superficially. The masseteric nerve generally has two fascicles at this level and was coaptated to the upper trunk of the facial nerve in an end-to-end fashion with 10/0 nylon epineural sutures under a microscope. The lower trunk (cervicofacial division) of the facial nerve was left intact (see Supplemental Video 1, which demonstrates the surgical procedure).

Supplementary video related to this article can be found at http://dx.doi.org/10.1016/j.bjps.2015.02.031.

A 15–20 mm linear incision was made in front of the region formed by the inferior border of the zygomatic arch and the mandibular notch on the healthy side to allow the zygomatic branches of the facial nerve that are responsible for smiling to be identified (Figure 2). The exposed area is located anterior to the parotid gland and contains several zygomatic and buccal branches of the facial nerve. One or two zygomatic branches that move the corners of the mouth more than the ocular region during electrostimulation should be selected as donor nerves. It is also important to leave at least one adjacent synergic branch so that the functions of the facial muscles on the healthy side are not adversely affected. During this procedure, another team worked on the patient's leg to harvest the sural nerve for the cross-facial nerve grafting. Cross-facial nerve grafting was then carried out after a skin tunnel had been

Figure 2 Incision used to identify the recipient zygomatic branches. X is the center of the area surrounded by the zygomatic arch above and mandibular notch below. The zygomatic major muscle (red), parotid duct, and anterior margin of the masseter are also indicated.

made between the bilateral cheeks and the nerve graft had been passed through the tunnel. The sural nerve was used in the reverse direction, and end-to-end microcoaptations between the selected zygomatic branches and the sural nerve graft were performed using 10/0 nylon epineural sutures on the healthy side. Microcoaptations were simultaneously performed on the affected side in the same fashion using 10/0 nylon epineural sutures. The recipient nerves used on the affected side were similar to the donor nerves employed on the healthy side (Figures 3 and 4). Simultaneous lower lid canthoplasty was carried out in patients who displayed severe lower eyelid ectropion at the time of surgery.

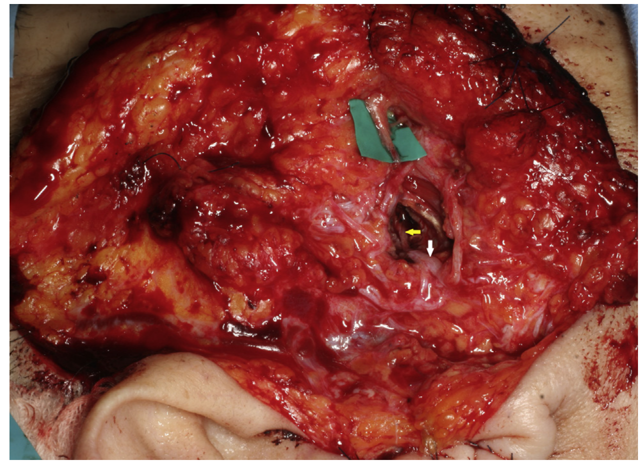

Figure 4 Intraoperative view of the right cheek area (Auricle is below). Yellow arrow is indicating the masseteric nerve, which is transected and transposed upward. White arrow is indicating the upper trunk of the facial nerve, which is turned over toward the masseteric nerve. Cross facial nerve graft (green rubber under it) is set to ready for microcoaptation to the distal zygomatic and buccal branches.

Results

The results of this study are summarized in Table 1. The mean duration of the postoperative follow-up period was 46 months (range: 22–65 months). Three of the 7 patients underwent simultaneous lower lid canthoplasty because of severe lower lid ectropion on the affected side. Cheek movement during biting was initially observed after 3–5 months (mean: 4 months), except in one case, in which long-term steroid therapy had been administered for concomitant clinical disease, and whilst the patient's

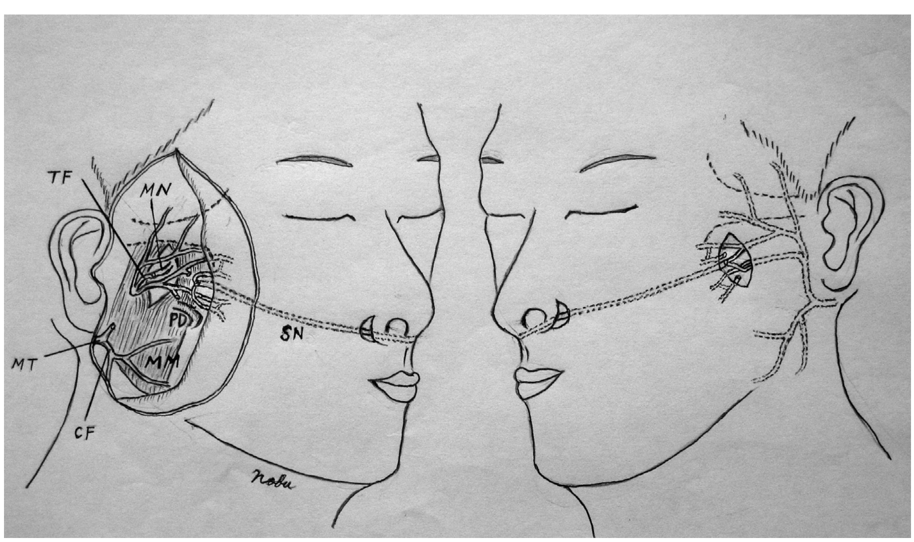

Figure 3 Schematic drawing of the procedure (Right side is paralyzed side.). Small bilateral incisions were made in the alar-cheek junction to assist with the passing of the nerve graft across the midline of the face. The end of the sural nerve graft on the affected side was used to produce microcoaptations with similar branches of the donor nerve on the healthy side. MT, main trunk of the facial nerve; CF, cervicofacial division of the facial nerve; TF, temporofacial division of the facial nerve; MN, masseteric nerve; SN, sural nerve graft; MM, masseter muscle; PD, parotid duct.

Please cite this article in press as: Yoshioka N, Tominaga S, Masseteric nerve transfer for short-term facial paralysis following skull base surgery, Journal of Plastic, Reconstructive & Aesthetic Surgery (2015), http://dx.doi.org/10.1016/j.bjps.2015.02.031

Table 1 Summary of patient data.

	Age/Sex	Disease	Interval before surgery (mo)	Onset of motion (mo)	Effortless smile	Eye closure	Ancillary procedures	HB grade	Follow-up (mo)
1	53/F	AN	4	3	No	Yes	No	III	65
2	56/F	AN	2	3	No	Yes	No	II	63
3	57/F	AN	12	No	No	No	Temporalis transfer	III	52
4	59/F	FNS	6	3	No	Yes	No	III	51
5	61/F	AN	4	4	No	Yes	Canthoplasty	III	43
6	63/F	AN	8	4	No	Yes	Canthoplasty	III	32
7	50/F	BT	6	5	No	Yes	Canthoplasty	II	22

F, female; AN, acoustic neuroma; FNS, facial nerve schwannoma; BT, brain tumor; HB, house-brackmann; mo, month.

muscle tone normalized she never recovered the ability to contract the paralyzed muscle. The latter patient underwent an additional temporalis muscle transfer to reanimate her paralyzed cheek. Six patients demonstrated good recoveries (House-Brackman Grade III or II) and were able to smile voluntarily by clenching their teeth. In addition, they were able to close their eyes tightly during biting (see Figure 5 and Supplemental Video 2, which demonstrates the postoperative facial appearance of the patient in Case 2). Coordinated eyelid movement was observed during biting in all patients who recovered the ability to contract their paralyzed muscles, and none of them experienced socially disturbing facial motions that adversely affected their daily lives. Whilst the frontalis muscle regained its tone in each case, none of patients were able to contract their frontalis muscles and so their eyebrows adopted a static symmetrical position. Although electrophysiological examinations detected reinnervation from the cross-facial nerve grafting in 3 of 7 patients, so far none of the patients have been able to achieve an effortless spontaneous smile. However, none of the patients have experienced impaired masticatory function or visible wasting of the masseter muscle.

Supplementary video related to this article can be found at http://dx.doi.org/10.1016/j.bjps.2015.02.031.

Discussion

Nerve transfers are indicated when the main trunk of the facial nerve is damaged or unavailable for grafting but the distal nerve branches and mimetic muscles remain viable. A number of nerves have been used for such transfers, with varying degrees of success, and the most common method is hypoglossal-facial nerve anastomosis with or without cross-facial nerve grafting.[3–5] Although the hypoglossal-facial nerve anastomosis procedure has been modified in an effort to improve its results and reduce donor site morbidity, there are no established nerve transfer procedures that exhibit all of the required characteristics.

The use of the masseteric nerve for facial reanimation surgery was first described by Spira in 1978.[7] Since then, several articles outlining the advantages of using the masseteric nerve for such procedures have been published.[12–17] Both the masseteric and hypoglossal nerves are powerful motor sources, as has been demonstrated by clinical and experimental studies.[19,20] In addition, there are several advantages to using the masseteric nerve rather than the hypoglossal nerve, including the proximity of the masseteric nerve to the facial nerve and the fact that it is associated with negligible donor site morbidity and a rapid recovery and has the potential to achieve an effortless spontaneous smile.[13,14]

No previous studies have described the donor site morbidities experienced after reanimation of the midface using the masseteric nerve. In addition to the patients described in this report, the author has used the masseteric nerve as a motor source for nerve transfers when treating several patients with incomplete palsy. So far none of these patients have exhibited eating dysfunctions or muscle atrophication. These findings indicate that some proximal branches still remain viable after the masseteric nerve has been divided on the deep part of the muscle.[14]

The main drawback of using motor nerves other than the facial nerve to reanimate facial muscles is that it can result in dissociated facial movements and a lack of spontaneity. Interestingly, effortless spontaneous smiles due to cerebral adaptation have been reported by some authors who used the masseteric nerve for facial reanimation.[12–14] Moreover, cerebral adaptation has also been observed in patients in which free muscle transfers involving the masseteric nerve were used for facial reanimation.[21,22] However, such adaptation does not occur in all patients, especially in elderly patients. Thus, further studies are needed to examine the development of spontaneous smiling via cortical adaptation after facial reanimation using the masseteric nerve. Although there seems to be a good chance of obtaining a spontaneous smile when only the buccal branches that are responsible for smiling are used as recipients for masseteric nerve transfers,[14,16] cross-facial nerve grafting is another possible way of achieving a spontaneous smile. The main argument against the use of cross-facial nerve grafting is the inconsistent results reported for the procedure.[23] However, a number of authors have reported that cross-facial nerve grafting is a reliable technique for reanimating incomplete paralysis.[24–27] It seems that the refinement and modification of cross-facial nerve grafting[28,29] has made this technique more effective and reliable.

Two previous articles have described the use of masseteric nerve transfer combined with cross-facial nerve grafting to treat facial paralysis.[14,16] However, the cross-

Figure 5 Case 2. Preoperative status at rest (A), upon closure of the eye (B), and during voluntary smiling (C). The patient's postoperative status (after 3 postoperative years) at rest (D), upon closure of the eye (E), and during voluntary smiling (F).

facial nerve grafting was used for eyelid animation, and the masseteric nerve transfer was used to reanimate the midface in these cases. Therefore, the masseteric nerve was the only nerve used for smiling in the latter procedures. Although the present study examined the combined use of cross-facial nerve grafting and masseteric nerve transfer to enable the dual motor innervation of a muscle involved in smiling, the cross-facial nerve grafting did not work well and so further refinement of this procedure is necessary. Our technique is similar to that described in a case report by Hontanilla et al.[30] Based on the postoperative images included in the latter report, the procedure seemed to produce good results. The main difference between the latter procedure and ours is that Hontanilla et al. performed secondary microcoaptations between the end of the cross-facial nerve graft and the zygomatic and buccal branches on the paralyzed side, whereas we performed the microcoaptations simultaneously. Nerve transfers combined with cross-facial nerve grafting can be performed as one-stage or two-stage procedures. One-stage procedures are generally preferred because of their simplicity.[23] Although one-stage procedures were employed in our cases, they did not result in spontaneous smiling, even in the patients in which electrophysiological reinnervation from the cross-facial nerve graft was detected. This is consistent with the findings of another report in which one-

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stage cross-facial nerve grafting was combined with hypoglossal-facial nerve transfer.[5] In cross-facial nerve grafting, motor endplate degeneration can occur before the sectioned nerve is attached to the axonal input from the contralateral side. In addition, the number of viable fascicles at the end of the cross-facial nerve graft is generally decreased because of the size discrepancy between the sural nerve graft and the donor facial nerve branches. Therefore, secondary microcoaptation between the viable fascicules of the nerve graft and facial nerve branches that have recovered their functions seems to have advantages over one-stage procedures. Furthermore, there is a possibility that nerve sprouts from the masseteric nerve could grow towards the cross-facial nerve graft before reaching the axonal input from the healthy side. Thus, it is necessary to evaluate the outcomes of cases involving secondary microcoaptation in order to allow meaningful comparisons of one- and two-stage procedures.

According to previous reports, facial movements are usually first observed within a few months of masseteric-facial nerve anastomoses being performed.[13–17] In this study, one patient who had undergone long-term steroid therapy did not exhibit any facial movements. Among the other patients whose facial movement was restored, the initial movements were seen within 5 months. Rapid recovery is an advantage for patients with sub-acute or even sub-chronic paralysis and increases the chances of functional recovery.

The author uses the upper trunk of the facial nerve as the recipient site for masseteric nerve transfers, which inevitably results in coordinated eyelid and mouth movements. However, such movements were minimal and did not cause problems for our patients. On the contrary, using the upper trunk enabled the patients to close their eyes tightly during biting. Moreover, the recovery of frontalis muscle tone can prevent additional brow lifting because the eyebrow maintains a static symmetrical position. However, such synkinetic eyelid movement can cause patients to feel uneasy during speaking or eating. Using buccal or zygomatic branches of the facial nerve other than the dominant branches responsible for eye motion for masseteric nerve transfers might be appropriate if additional procedures are employed to reanimate the eye. Furthermore, the proximity of the masseteric nerve to the facial nerve enables selective nerve transfer, which might reduce mass movement, and is an advantage for patients with incomplete palsy because selective masseteric-zygomatic branch anastomosis without an interposition nerve graft can be performed in such cases. Regarding the reanimation of the lower lip depressors, which is not included in the procedure described in this report, the anastomosis of the hypoglossal nerve transfer to the marginal mandibular branch of the facial nerve in a side-to-end fashion with or without an interposition nerve graft might be another way of achieving total facial reanimation.[31]

Previous basic and clinical anatomical studies have identified the masseteric nerve. Several studies have described different techniques for localizing the masseteric nerve.[32–35] In addition, the masseteric nerve can be reliably localized using constant anatomical landmarks, regardless of the patient's characteristics.[36] The masseteric nerve always passes from the infratemporal fossa through the area that is formed by the inferior border of the zygomatic arch and the mandibular notch, before reaching the medial surface of the masseter muscle, and this region is palpable intraoperatively. Therefore, blunt dissection of the masseter muscle along its fibers towards the deeper parts of the muscle located in this area makes it possible to expose the nerve without difficulty.

Conclusions

Masseteric nerve transfer using the upper trunk of the facial nerve as a recipient nerve is an alternative method for selective reanimation of the midface after short-term facial paralysis. The masseteric nerve is available for facial nerve transfers and does not cause donor site morbidities.

Ethics

The study was performed according to the institutional ethical guidelines.

Funding source

This study did not receive any funding.

Conflicts of interest

None.

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