Functional Outcome of single-stage facial reanimation surgery with radical parotidectomy

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Running Title
Single-stage facial reanimation with parotidectomy

Highlights
This research analyzed functional outcome of single-stage facial reanimation in radical parotidectomy.
The selective reinnervation group showed favorable outcome in both clinician-based and automated facial assessment tools.

Facial Disability Index scores indicated fair physical and social/well-being functions.

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**Conflict of Interest**

The authors declare that they have no conflict of interest.

**Author Contributions**

Conceptualization: JYJ, EJC. Data curation: JYJ, MKP, MWS, SHA, EJC. Formal analysis: JYJ. Methodology: JYJ, SDK, EJC. Visualization: SDK. Writing - original draft: JYJ. Writing - review & editing: all authors.
Abstract

Background

Facial nerve sacrifice during radical parotidectomy impairs quality of life. This study assessed the effectiveness of simultaneous single-stage facial reanimation surgery with radical parotidectomy in restoring facial function.

Methods

A retrospective analysis was conducted on patients who underwent single-stage facial reanimation with radical parotidectomy. Techniques included selective reinnervation and orthodromic temporalis tendon transfer. Outcomes were measured using modified House-Brackmann and Terzis grades, Emotrics facial assessment, and the Facial Disability Index (FDI).

Results

Among thirteen patients (median age 54, 69% male), ten received selective reinnervation. Nine of these patients showed improved results of House-Brackmann grade III and Terzis grade 4-5. The remaining three underwent tendon transfer, achieving moderate functional outcomes. Emotrics analysis indicated balanced facial symmetry in the selective reinnervation group. FDI scores reflected satisfactory physical and social/well-being functions.

Conclusions

Single-stage facial reanimation effectively restores facial function in patients undergoing radical parotidectomy. This approach offers significant benefits in early facial function recovery.

Keywords

Facial reanimation; reinnervation; parotidectomy; facial palsy; parotid cancer
Introduction

Tumors of the parotid gland are primarily managed with surgery. Malignant tumors often require ablative surgery involving sacrifice of the facial nerve when the tumor involves the nerve. According to previous studies, the incidence of facial nerve involvement by parotid malignancies was 12-15%[1, 2]. Incidences of temporary and permanent postoperative facial palsy following parotidectomy were 3.7-21.8% and 0.9-4% respectively[3, 4]. Especially, facial nerve sacrifice is necessary in many parotid malignancies for sound oncological outcome when a malignant parotid tumor invades the main trunk of the facial nerve[5]. Facial nerve sacrifice inevitably leads to facial paralysis, resulting in both functional and psychological deterioration. Functional problems associated with facial palsy include corneal injury, visual disturbance, and difficulties with facial expression, eating, drinking, and speaking[6]. A high proportion of patients with facial palsy suffer from psychosocial difficulties, namely clinically significant levels of anxiety and depression, low quality of life, poor social function, and high levels of appearance-related distress[7].

Reconstruction after ablative surgery for advanced parotid tumors had often been neglected[8]. Protraction of reconstructive surgery may lead to functional discomfort for a patient for a long time. Prolonged facial paralysis involves atrophy of the facial muscles innervated by the nerve, leading to persistent facial asymmetry. Thus, timely or immediate restoration of facial function would be beneficial for such patient. To the best of our knowledge, research studies on single-stage reanimation surgery conducted simultaneously with radical parotidectomies have been scarce[9].

The traditional method for facial nerve reanimation is anastomosis between the main trunk of the facial nerve and each peripheral branch with interposition nerve graft such as sural nerve or greater auricular nerve. This method has limitations of a weak motor power, especially during smiling and synkinesis of facial muscles. In recent studies, the masseteric nerve has been spotlighted as an important power source since it serves as a powerful motor source and rarely associated with synkinesis[10]. Selective reinnervation utilizing respective nerves as power sources for eye closure, smile excursion, and maintenance of lower lip tone can restore facial nerve function while preventing from synkinesis. When selective reinnervation is unavailable, orthodromic temporalis tendon transfer can be an option to reanimate smile.
The objective of this study was to analyze outcomes of single-stage facial reanimation surgeries during radical parotidectomy using selective reinnervation and orthodromic temporalis tendon transfer.

Materials and Methods

Study design

This retrospective study was approved by the Institutional Review Board (IRB No. 2308-086-1458). The research was conducted in accordance with the Helsinki Declaration of 1975 as revised in 1983. Patients with parotid tumors who underwent a single-stage facial reanimation surgery with radical parotidectomy between September 2019 and October 2022 with at least eight months of follow-up were included. Clinicopathological data including age, sex, histopathology, tumor side, staging, prior surgery, the interval between surgeries, surgical procedures performed, adjuvant therapies, complications, oncologic outcome, preoperative and postoperative facial nerve functions, and patient-rated functional outcomes were reviewed.

Preoperative and postoperative observer-rated subjective facial nerve functions were analyzed with modified House-Brackmann Grading System[11], Terzis Facial Grading System[12], and Chuang smile excursion score. For postoperative objective facial nerve function analysis, Emotrics software (Massachusetts Eye and Ear Infirmary, Boston, MA)[13] was utilized at the last follow-up available. Emotrics created the vertical midline perpendicular to interpupillary distance and used 68 points at facial landmarks confirmed and adjusted by the authors. It automatically calculated several distances and angles (Supplementary Figure 1). Both at rest and during smile activation with jaw clenching, commissure position and commissure height deviation data were collected.

Postoperative patient-rated outcome measure using Facial Disability Index (FDI) was analyzed, including physical and social/well-being function subscales[14]. Subjective pain and cosmetic satisfaction were assessed with visual analog scale (VAS) for pain score (0, no pain; 5, fair; 10, most severe pain) and 5-point Likert scale for cosmetic satisfaction score (1, very unsatisfied; 2, unsatisfied; 3, neutral; 4, satisfied; and 5, very satisfied).

Operative Technique
All patients received definitive resection of the gross disease including radical parotidectomy and surgery for facial reanimation simultaneously. Main procedures of the surgeries were conducted by a single otolaryngologist-head and neck surgeon under intraoperative neuromonitoring (IONM) of facial nerve. Needle electrodes were placed in four areas innervated by branches of facial nerve: temporal, zygomatic, buccal, and marginal mandibular branches. Ground and stimulator electrodes were placed at the sternum area. A stimulation probe was available in the operation table. Neumuscular junction blockade was reversed during surgery. IONM assisted surgeon to identify the main trunk and each branch of the facial nerve during radical parotidectomy. Peripheral branches of the facial nerve were traced and identified to their greatest possible number and extent before severing the portion involved by the tumor. Mastoid drilling was conducted by otologists when temporal bone resection or subtotal petrosectomy were indicated for the resection of the primary tumor or when there was a need to expose more proximal part of the facial nerve due to involvement of the main trunk. Therapeutic neck dissections were performed for clinically positive lymph nodes. Elective neck dissections were performed for T3-4 tumors. After severing the portion of the facial nerve involved by the tumor, facial nerve reanimation was performed simultaneously either by selective facial nerve reinnervation (triple/dual reinnervation) or orthodromic temporalis tendon transfer (OTTT).

(1) Selective facial nerve reinnervation (Selective neurorrhaphy between nerve to zygomaticus major muscle-masseteric nerve (5-7) & nerve to orbicularis oculi muscle-proximal facial nerve stump (7-7))

For selective reinnervation of nerve to zygomaticus major muscle, masseteric nerve was identified with the help of the IONM stimulator (Supplementary Video 1). Tension-free epineural neurorrhaphy was applied between the masseteric nerve and the nerve to zygomaticus major muscle. An autologous interposition nerve graft was utilized to fill the gap in nerve continuity between the nerve to orbicularis oculi muscle and proximal facial nerve stump (7-7). Nerve grafts were harvested from the operating field if available, for example, the greater auricular nerve graft (n=4, case No. 1, 3, 8, 10) from the field of neck dissection, the antebranchial cutaneous nerve (n=2, case No. 2, 9) from radial forearm free flap donor site, or the sural nerve (n=4, No. 4, 5, 6, 7) when the former two nerves were unavailable or when its generous length was necessary. When available, the nerve to orbicularis oris muscle was anastomosed to ansa cervicalis nerve (12-7) to maintain the tone of the lower lip. Dual reinnervation refers to reinnervations of nerve to zygomaticus major muscle with masseteric nerve and nerve to orbicularis oculi muscle.
with proximal facial nerve stump. Triple reinnervation refers to the procedure of dual reinnervation plus reinnervation of nerve to orbicularis oris muscle with ansa cervicalis nerve (Figure 1).

(2) Orthodromic temporalis tendon transfer

When selective reinnervation was unavailable, orthodromic temporalis tendon transfer (OTTT) was conducted for dynamic reconstruction of the midface and smile. The coronoid process, the insertion point of the temporalis muscle, was identified. Coronoidectomy was conducted to mobilize bone segment with the attached temporalis tendon. After mobilizing the temporalis tendon with coronoid process, a hole was created to the bone segment using a drill. To extend the reach of the temporalis tendon, the palmaris longus tendon harvested from the radial forearm free flap donor site or a strip of the fascia lata from the anterolateral thigh flap donor site was used. The palmaris longus tendon or the strip of the fascia lata was fixed to the temporalis tendon using a hole created at the coronoid process. The other end of the palmaris longus tendon or the fascia lata strip was divided into two branches. These branches were fixed to the upper lip and the lower lip at the philtrum through submucosal tunnels (Figure 2).

Statistical Analysis

Statistical analysis of quantitative measurements obtained from Emotrics software was conducted using SPSS v.27 (IBM Corp.). Postoperative Emotrics data of selective reinnervation group were compared between the affected side and the normal side using paired t-test. All statistical tests were two-sided and statistical significance was defined as $p<.05$. 
Results

Patient characteristics

We identified 14 patients with parotid tumors who underwent single-stage facial reanimation surgery during radical parotidectomy. One patient with a follow-up period shorter than five months was excluded. Thus, a total of 13 patients were finally analyzed. Demographic, histopathologic, and preoperative facial nerve grade data of patients are presented in Table 1. Patients were primarily males (n = 9, 69%) with a median age of 54 (range, 21-73) years. Majority (n = 10, 76.9%) of the final histopathologic diagnoses were malignant tumors, including adenoid cystic carcinoma (n = 3, 23.1%), salivary duct carcinoma (n = 3, 23.1%), acinic cell carcinoma (n = 1, 7.7%), mucopidermoid carcinoma (n = 1, 7.7%), secretory carcinoma (n = 1, 7.7%), and squamous cell carcinoma (n = 1, 7.7%). Other benign histopathologic diagnoses were facial nerve schwannoma and recurred pleomorphic adenoma. All tumors were either invading or completely encasing the facial nerve, which made sacrifice of the facial nerve inevitable. Among patients with malignant tumors, final pathologic T stagings according to the American Joint Committee on Cancer 8th edition were T4a (n = 7) and T3 (n = 3). Six patients underwent a previous surgery, with the interval between surgeries ranging from 2 months to 30 years. Their preoperative facial nerve grade according to the House-Brackmann Grading System varied from stage I to V.

Performed surgical procedures

Facial reanimation procedures conducted for each patient are presented in Table 1. All patients underwent radical parotidectomy including facial nerve sacrifice. In 9 patients (except for patients No. 5 and 11), mastoid drilling was conducted, and the proximal facial nerve was identified. Facial reanimation surgery was performed in a single-stage fashion. Ten patients (No. 1~10) underwent single-stage, multiple selective reinnervations (dual or triple reinnervation) including masseteric nerve. Three patients (No. 11~13) underwent OTTT.

Among the selective reinnervation group, dual reinnervation was conducted for four cases and triple reinnervation was performed for six cases. Local or free flaps, including sternocleidomastoid muscle rotational flap (n = 4), temporalis muscle rotational flap (n = 1). Vascularized free flaps were used to cover avascular nerve grafts while simultaneously performing facial contour reconstruction, with radial forearm free flaps (n=3) or anterolateral...
thigh free flaps (n=4), for the patients requiring postoperative radiation therapy. Free flaps were de-epithelized after harvest and inset as adipofascial flaps to augment the facial volume.

OTTT was conducted in three patients because selective reinnervation of nerve to zygomaticus major muscle with masseteric nerve was infeasible intraoperatively. In patient No. 11, recurred tumor invaded the distal portion of the nerve to the zygomaticus major muscle. Thus, facial reanimation with OTTT with palmaris longus tendon was conducted. In patient No. 12, it was infeasible to perform selective reinnervation since the patient had established facial palsy of House-Brackmann grade V preoperatively for years. Consequently, OTTT was conducted. In patient No. 13, selective reinnervation was infeasible since zygomatic and buccal branches of the facial nerve were involved by tumor in frozen section. Thus, OTTT with fascia lata was conducted.

**Facial functional result**

The median postoperative follow-up period was 14 months (mean, 17.2 months; range, 8-30 months). Postoperative facial functional results are presented in Table 2. These results represented the functional outcome at the latest follow-up. In the reinnervation group, facial function in nine out of ten patients were modified House-Brackmann grade III and Terzis grade 4 to 5 (grade 4, n = 4, 40%; grade 5, n = 5, 50%) (Supplementary video 2).

Patient No. 3 who already had preoperative facial nerve palsy of House-Brackmann grade IV showed postoperative facial functional result of modified House-Brackmann grade V and Terzis grade 1. Patients in the OTTT group demonstrated facial functional results of modified House-Brackmann grade IV-V and Terzis grade 2 (Supplementary video 3).

The results of the Emotrics analysis of selective reinnervation group are presented in Figure 3.

In the selective reinnervation group, mean (± SD) oral commissure positions of affected and normal functioning contralateral sides were 27.53 ± 3.14 and 29.62 ± 6.41mm (p = .147) at rest and 31.28 ± 5.41 and 33.19 ± 6.45mm (p = .341) when smiling, respectively, showing no significant difference between affected and normal sides. Mean oral commissure heights of affected and normal functioning contralateral sides also had no statistically significant difference both at rest (10.48 ± 4.79 vs. 8.13 ± 4.17, p = .101) and when smiling rest (8.23 ± 6.13 vs 7.46 ± 4.20, p = .670) either. In the orthostatic temporalis tendon transfer group, mean oral commissure positions of affected and normal sides were 33.30 ± 10.42 and 33.29 ± 5.55 (p = .998) at rest and 31.57 ± 3.86 and 37.02 ± 5.30
(p = .023) when smiling, respectively. Mean oral commissure heights of affected and normal sides were 4.99 ± 4.57 and 4.01 ± 1.88 (p = .650) at rest and 5.08 ± 3.77 and 1.09 ± 4.13 (p = .416) when smiling, respectively.

**Patient-rated outcome measures**

Postoperative patient-rated outcome measures using FDI, pain VAS, and cosmetic satisfaction score were available except for two patients (patients No. 1 and 12) (Supplementary Table 1). The median postoperative follow-up period at postoperative patient-rated outcome assessment was 10 months (range: 3-22 months). All subjective pain scores were 4 or less. Cosmetic satisfaction score revealed that six patients were satisfied with their cosmetic outcomes (very satisfied, n = 2; satisfied, n = 4), four were neutral, and one was very unsatisfied. Mean FDI physical, FDI social/well-being, and total FDI scores were 68.2 (SD: 18.5, range, 30-100), 63.3 (SD: 23.5, range, 24-96), and 131.5 (SD: 37.1, range, 74-186), respectively.

**Adjuvant treatment and oncologic result**

For postoperative adjuvant treatment, five patients received postoperative radiotherapy only, three patients underwent postoperative concurrent chemotherapy. One patient underwent postoperative chemotherapy only, due to prior concurrent chemoradiotherapy before salvage surgery. At the latest follow-up available, seven patients remained in a no-evidence-of-disease (NED) status, while the other six patients had progressive diseases. Three patients developed distant metastasis to the lung and one had distant metastasis to the lung and the spine. In two cases, radical parotidectomy and facial reanimation were conducted for salvage operation due to failure of the initial concurrent chemoradiation therapy. These two patients already had lung metastasis before the salvage surgery. Thus, metastasectomy or stereotactic ablative radiotherapy was conducted to control the lung metastasis after parotid surgery. However, the disease progressed in these patients, with one patient developing local recurrence and lung metastasis and the other developing local recurrence and distant metastasis to the lung, femur, and ribs.
Discussion

This study investigated facial functional results of single-stage facial reanimation surgery conducted simultaneously with radical parotidectomy. Selective reinnervation and OTTT were performed for facial reanimation. Clinician-based and automated facial assessment tools were utilized for outcome analysis. Results demonstrated good clinician-based functional outcomes – modified House-Brackmann grade III and Terzis grade 4-5 in nine out of ten among selective reinnervation cases. The automated (Emotrics) assessment of postoperative oral commissural positions showed no significant difference between the operated and normal contralateral sides.

While ablative surgery for parotid tumors may involve sacrifice of the facial nerve[1, 2], its immediate functional restoration received relatively little attention[8]. A previous study has revealed that 68.8% of patients undergoing total parotidectomy with facial nerve sacrifice are not receiving concurrent facial reanimation. Research studies on the functional results of a single-stage reanimation surgery conducted simultaneously with radical parotidectomies have been scarce[9]. To the best of our knowledge, this study is the first to investigate the functional results of single-stage facial reanimation surgery conducted concurrently with radical parotidectomy in East Asia.

If reconstructive surgery is delayed from the sacrifice of the facial nerve, this can lead to prolonged facial paralysis and functional deterioration for the patient. Prolonged facial paralysis may cause atrophy of facial muscles, resulting in permanent facial asymmetry. Immediate facial reanimation would be advantageous to patients in that the period of time suffering from facial paralysis can be shortened. Furthermore, previous studies have shown that early facial reanimation is associated with better functional outcomes. For example, early neurorrhaphy within 1 year with an interposition nerve graft resulted in better facial functional outcomes when compared to delayed treatment.[15]. In another study utilizing hemihypoglossal-facial neurorrhaphy, hemihypoglossal-facial neurorrhaphy with grafts, and masseter-facial nerve transfer, delayed surgery over 2 years after the injury was associated with worse outcomes.[16] Simultaneous facial reanimation may also be good for a reconstructive surgeon since there is no adhesion and peripheral branches of the facial nerve can be readily identified during parotidectomy, making the selective reinnervation strategy more feasible.
In our study, the selective reinnervation group showed relatively good postoperative functional outcomes. Traditionally, anastomosis between the main trunk of the facial nerve and peripheral branches with an interposition nerve graft has been performed as a method for facial reanimation. However, synkinesis of upper and lower division has been pointed out as a limitation when this technique is performed at the main trunk level. Synkinesis involves unintended movements such as oral excursion when closing one’s eye, resulting in a long-standing discomfort and functional deterioration. Treatment of synkinesis is difficult. Thus, prevention is important in facial reanimation. This can be prevented with selective reinnervation, which uses separate nerves as power sources for eye closure, smile excursion, and lower lip tone maintenance. To restore dynamic movement of smile excursion, recent research has highlighted the masseteric nerve as an important power source[10]. In a retrospective study comparing interposition nerve graft and masseteric nerve transfer, masseteric nerve transfer resulted in strong oral commissure excursion and avoided obvious synkinesis.[17] In our study, using masseteric nerve for reinnervation of zygomatic major muscle also resulted in a good functional outcome of lip movement as shown in the Emotrics analysis. Clinician-assessed functional outcome of the selective reinnervation group grossly seemed to be superior to that of the OTTT group.

However, patient No.3 showed poor functional outcomes even after selective reinnervation with masseteric nerve. He had preoperative facial paralysis of modified House-Brackmann grade IV for 14 months due to the prior surgery for salivary duct carcinoma of parotid gland. After single-stage selective reinnervation with masseteric nerve, the functional outcome 7 months after surgery showed modified House-Brackmann grade V and Terzis grade 1, revealing no recovery of facial movement. It could be inferred that the prior long-standing facial paralysis might be a prognosticator for poor facial functional outcome, which is in agreement with the literature.[16]

Three patients underwent OTTT in our study. In cases where the tumor invasion is too extensive to preserve each branches of the facial nerve, or there is a long-standing facial palsy with distal atrophy, selective reinnervation is not feasible. In these cases, regional muscle transposition can be considered an option for facial reanimation. Examples of regional muscle transposition include temporalis, masseter, and the anterior belly of digastric muscles, while temporalis muscle transfer is widely performed. Traditional “antidromic” temporalis muscle transfer involves detaching the muscle from the calvarium insertion site, transferring it to the zygomatic arch, and fixing to the modiolus and lateral nose. However, deformity of the donor site and the excessive tissue bulk at the
zygomatic arch area were reported as problems of antidromic temporalis transfer. To overcome these problems, "orthodromic" temporalis muscle transfer (OTTT) detaches the temporalis muscle from the coronoid process insertion site and fixes it to oral commissure. It is a less extensive procedure than free flap transfer. In addition, it enables a clenching smile after rehabilitation, allowing for social interaction with facial expression. Thus, OTTT can be a good surgical option for restoration of irreversible facial paralysis when selective reinnervation is infeasible.

The FDI consists of 10 Likert-type questions that evaluate physical and social/well-being function. The scale for physical function ranges from -25 to 100 and that for social/well-being function ranges from 0 to 100, with a higher number indicating a more favorable outcome[14]. In a study analyzing thirty unilateral facial palsy patients with stable facial function, including about two thirds of patients who underwent some facial reanimation procedures, the mean FDI physical function score was 63.8 and the mean FDI social/well-being score was 63.3[18]. In our study, mean values of FDI physical function and FDI social/well-being function score were 68.2 and 63.3, respectively, comparable to results of the previous study. It has been noted that FDI social/well-being score has poor correlation with observer-assessed facial functions[18, 19]. Therefore, even though observer-rated and physical function scores were favorable, FDI social/well-being function score could be relatively low. This could be attributed to the fact that most patients did not have facial palsy before the surgery, possibly leading to high expectations for functional outcomes of facial reanimation surgery. Thus, further prospective studies are warranted to enhance both objectively assessed functional outcomes and patient-rated subjective outcomes.

In this study, we focused on functional outcomes of single-stage facial reanimation surgery following radical parotidectomy utilizing both clinician-based assessments and automated facial assessment tools. Currently, no randomized studies are comparing selective reinnervation and interposition nerve grafts. Conducting such studies is challenging due to the rarity of radical parotidectomy with extensive facial nerve root sacrifice cases and the inherent differences in surgical outcomes. Despite these challenges, our study demonstrates the potential benefits of selective reinnervation, which could provide more consistent and satisfactory functional results. Further comparative studies are warranted to objectively compare different methods of facial reanimation to optimize functional outcomes and improve the quality of life of patients undergoing parotidectomy with facial nerve sacrifice.
Conclusion

In radical parotidectomy with facial nerve sacrifice, single-stage facial reanimation surgery with selective reinnervation using masseteric nerve or OTTT resulted in favorable facial functional outcomes. This surgical procedure may benefit this patient population with earlier restoration of facial function.
References


Table 1. Demographic, histopathologic, and preoperative facial nerve grade data, and conducted surgical procedures

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<tr>
<th>Case No.</th>
<th>Sex</th>
<th>Age</th>
<th>Side</th>
<th>Histopathologic diagnosis (The 4th edition of WHO classification of head and neck tumors)</th>
<th>TNM staging</th>
<th>Previous surgery (Interval between surgeries, month)</th>
<th>Preoperative facial nerve grade (House-Brackmann Grading System)</th>
<th>Procedure</th>
<th>Flap for contour or skin defect</th>
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<td>59</td>
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<td>2</td>
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<td>21</td>
<td>R</td>
<td>Secretory carcinoma</td>
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<td>SCM, RFFF</td>
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<td>IV</td>
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Orthodromic temporalis tendon transfer, fascia lata

Abdominal fat obliteration for STP, gold weight insertion

Orthodromic temporalis tendon transfer, facial lata

SCM

Abbreviations: F, female; M, male; L, left; R, right; RFFF, radial forearm free flap; SCM, sternocleidomastoid muscle rotational flap; ALTFF, anterolateral thigh free flap; TM, temporalis muscle rotational flap, STP, subtotal petrosectomy; SCM, sternocleidomastoid.
Table 2. Functional outcome

<table>
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<tr>
<th>Case No.</th>
<th>Surgery for FN reanimation</th>
<th>Preoperative facial nerve grade (H-B)</th>
<th>Latest facial nerve grade (modified H-B)</th>
<th>Terzis grade</th>
<th>Chuang smile excursion score</th>
<th>Postoperative follow-up period (month)</th>
<th>Interval to the first recovery sign (month)</th>
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Abbreviation: FN, facial nerve; H-B, House-Brackmann
Figure Legends

Figure 1. Selective reinnervation (triple reinnervation)

A. Schematic illustration of trip reinnervation

B. Intraoperative view after selective reinnervation. (1) The interposition graft between the main trunk of facial nerve and nerve to orbicularis oculi muscle. (2) Masseteric nerve coapted to nerve to zygomaticus muscle. (3) Ansa cervicalis nerve coapted to nerve to orbicularis oris muscle.

Figure 2. Orthodromic temporalis tendon transfer

A. Schematic illustration of orthodromic temporalis tendon transfer

B. Intraoperative view after orthodromic temporalis tendon transfer.

Figure 3. Postoperative Emotrics results of selective reinnervation and orthostatic temporalis tendon transfer group

Abbreviation: OTTT, orthodromic temporalis tendon transfer
Figure 1.
Figure 2.

A

B

Figure 3.

Selective reinnervation

OTTT

- Affected side
- Normal side
## Supplementary Materials

### Table S1. Postoperative patient-rated outcome measures

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Assessed postoperative follow-up period</th>
<th>Pain VAS</th>
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Abbreviation: VAS, visual analogue scale; FDI, Facial Disability Index.

### Figure S1. Emotrics Analysis of postoperative resting and big smile expression state.
Supplementary Video 1. Selective reinnervation (Dual reinnervation) surgical procedures
The masseteric nerve is identified and confirmed by intraoperative nerve stimulation. Tension-free epineural neurorrhaphy is applied between the masseteric nerve and the nerve to zygomaticus major muscle. An autologous interposition nerve graft, the antebranchial cutaneous nerve harvested from the radial forearm free flap donor site in this video, is placed between the nerve to orbicularis oculi and facial nerve trunk and neurorrhaphy is conducted.

Supplementary Video 2. Postoperative functional result of selective reinnervation.
Supplementary Video 3. Postoperative functional result of orthodromic temporalis tendon transfer.