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ORIGINAL ARTICLE

Reconstructive

Free Vastus Lateralis Functional Muscle Transfer: An Approach to Facial Reanimation and Reconstruction in Radical Parotidectomy

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Background: Our report focuses on a new method for reanimating the facial nerve and reconstructing soft tissue after radical parotidectomy due to malignant parotid tumor infiltration. We found that using the free vastus lateralis functional muscle transfer (FVL-FMT) can be effective.

Methods: FVL-FMT is an immediate single-stage reconstruction technique. It uses 2 branches of the vastus lateralis motor nerve—the descending (type 1) and oblique (type 2) branches—to supply the transferred free functional muscle. The descending branch also acts as a vascularized nerve graft that reconnects the facial nerve and its branches. It was used in a review of patients with stage IVA parotid cancer who underwent radical parotidectomy, with facial function assessed using modified House–Brackmann and Yanagihara facial nerve grading scales.

Results: Seven patients underwent facial nerve reconstruction, 6 with type 1 and 1 with type 2 FVL-FMT. Three patients regained normal ocular function, whereas 4 achieved moderate dysfunction for the lower midface. The modified House–Brackmann scores were III (n = 3, 42.9%), IV (n = 2, 28.6%), and V (n = 2, 28.6%), whereas the Yanagihara system scores ranged from 4 to 30. All patients had minimal synkinesis, and 6 (86%) achieved acceptable symmetrical resting tone. All flaps survived, and ocular complications and feeding problems were absent.

Conclusions: Immediate facial nerve reconstruction can improve the quality of life for patients with facial palsy after surgery. The vastus lateralis functional muscle transfer is a reliable method that restores function and appearance in facial nerve defects. *(Plast Reconstr Surg Glob Open 2025;13:e6557; doi: 10.1097/GOX.0000000000006557; Published online 19 February 2025.)*

INTRODUCTION

Facial nerve reconstruction after treating malignant tumors of the parotid gland can be challenging due to tissue loss, nerve damage, fibrosis, and poor wound healing. Loss of facial nerve function can lead to functional, aesthetic, and psychosocial issues. Although nonvascularized sensory nerves, such as the greater auricular or sural nerve, are commonly used in grafting, some experts recommend vascularized options such as the thoracodorsal or lateral femoral cutaneous nerves[1,2] for complex cases, despite being technically challenging.[1,3–6]

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This report introduces a new flap technique called the free vastus lateralis functional muscle transfer (FVL-FMT). This flap can restore the function and appearance of complex facial nerve defects. The FVL-FMT uses the neurovascular pedicle (NVP) from 2 branches of the vastus lateralis motor nerve (VLMN): the proximal oblique branch (ob-VLMN) and the distal descending branch (db-VLMN). These branches are transferred with their respective blood supply from the lateral circumflex femoral (LCF) vessels. This study reports 2 variations of the flap: in type 1, the descending NVP supplies the functional musculocutaneous flap (Fig. 1), whereas in type 2, the oblique NVP serves this function (Fig. 2). In both types, the db-VLMN serves as a vascularized nerve graft to reconstruct the facial nerve and its branches through a series of end-to-end (ETE) and end-to-side (ETS) perineurotomy coaptations (Fig. 3).

Disclosure statements are at the end of this article, following the correspondence information.

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Takeaways

Question: Is there a reliable single-stage technique for facial nerve reanimation in radical parotidectomy patients?

Findings: This article reviews the free vastus lateralis functional muscle transfer technique and its results. Three patients had normal eye movements, whereas 3 others showed moderate dysfunction. Four patients also had moderate dysfunction in the regional nasolabial fold and oral scores. In the modified House–Brackmann scale, grades were III (n = 3), IV (n = 2), and V (n = 2). All had little synkinesis, and 6 achieved a symmetric resting tone.

Meaning: Immediate facial nerve reconstruction with free vastus lateralis functional muscle transfer can enhance the lives of patients with surgery-induced facial paralysis by restoring function and appearance.

This report details the surgical techniques used in FVL-FMT and its preliminary outcomes in facial reanimation and soft tissue reconstruction.

PATIENTS AND METHODS

A hospital ethics review committee (B-2021-403) has approved this case series, which adheres to the Declaration of Helsinki. Patients have given their consent for the publication of their clinical data, photographs, and videos.

The Nippon Medical School Hospital Database was used to review the medical records of patients who underwent soft tissue reconstruction and facial nerve reanimation using FVL-FMT between April 2013 and January 2023. Four of the 11 patients identified were excluded due to insufficient follow-ups (<12 mo) and additional static procedures. The medical chart review obtained demographic, clinical, treatment, and reconstruction data (flap size, nerve graft length, and nerve gap). The nerve gap was determined from the length of db-VLMN utilized in facial reanimation, as shown in Table 1.

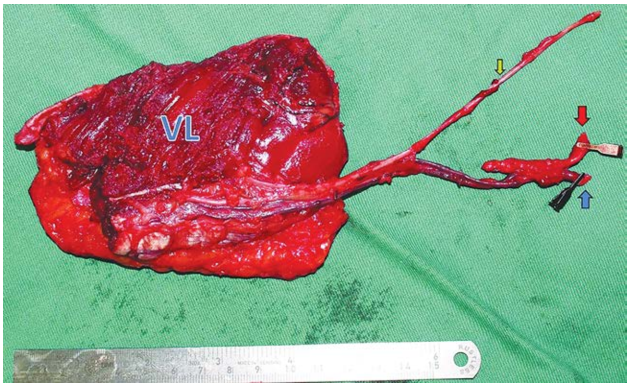

Fig. 1. A photograph of a harvested type 1 FVL-FMT showing the NVP. The descending branch of the VLMN (green arrow) supplies the functional muscle. The db-LCF vein (blue arrow), db-LCF artery (red arrow), and VL muscle are also shown.

The study focused on 7 patients with stage IVA parotid cancer (4 men and 3 women) with a mean age of 49 (range 13–79) years. Three patients (patients 3, 4, 6) presented with preoperative facial palsy. Four patients (patients 1, 4, 6, 7) underwent adjuvant radiotherapy (RT) (range 50–60 Gy). The patients stayed in the hospital for a week and were given discharge instructions for facial massages and exercises. Photographs, videos, and facial nerve grading evaluation using the modified House–Brackmann (HB_2) and Yanagihara facial nerve grading system (YS)[7,8] were taken during scheduled follow-ups. The HB_2 system is a 6-point scale for regional assessment that includes sequelae such as contractures, synkinesis, and spasms. A score of VI indicates total paralysis. The YS is a 40-point scale that pays no particular attention to sequelae; a score of 40 means no palsy.

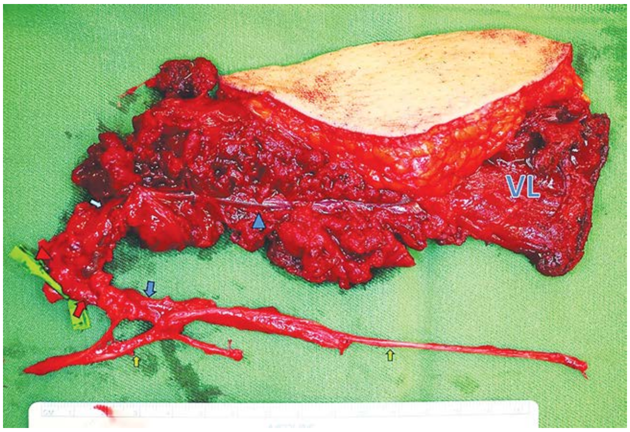

Fig. 2. A photograph of a harvested type 2 FVL-FMT showing the NVPs. The ob-VLMN (light blue arrow) supplies the functional muscle and will be coapted ETS to the db-VLMN (green arrow) during neurorrhaphy. The db-LCF vein (blue arrow), db-LCF artery (red arrow), ob-LCF vein (blue arrowhead), ob-LCF artery (red arrowhead), and VL muscle are also shown.

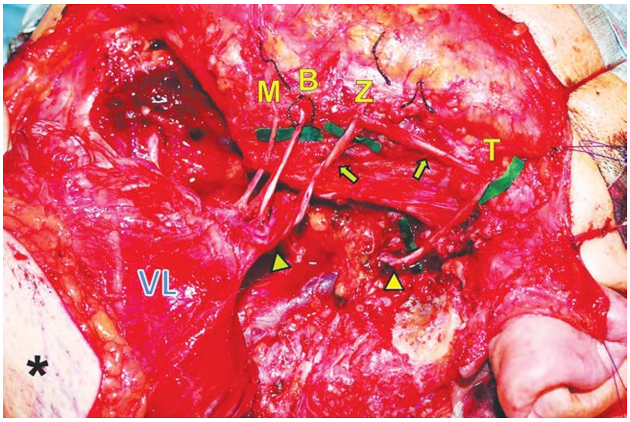

Fig. 3. Photographs showing the ETE and ETS coaptations in type 1 FVL-FMT. The following features are shown: facial nerve stump (yellow arrowhead), db-VLMN (green arrows), vascular pedicle (green arrowhead), temporal branch (T), zygomatic branch (Z), buccal branch (B), marginal mandibular branch (M), and VL, and * indicates the skin paddle.

Table 1. Demographic, Clinical, Treatment, and Reconstruction Data

Patient	Age, y/ Sex	Tob	Vasc	Diagnosis	Side	TNM (Union for International Cancer Control 8th ed.)	RT	Chemo	Flap Size (cm)	VL Length (cm)	NGL (cm)	NG	FVL-FMTt	Flap Survival
1	45/M	+	−	Adenocarcinoma	R	pT2N2bM0	50 Gy	TS-1	8 × 4	8	11	6	1	+
2	63/F	−	−	Adenocarcinoma	R	pT2N2b M0	—	—	9 × 3	8	17	8	1	+
3	79/M	+	+	Carcinoma ex pleomorphic adenoma	R	pT4aN0M0	—	—	10 × 4	10	13.5	8	1	+
4	69/F	−	+	Sarcomatoid carcinoma	R	pT4aN2bM0	60 Gy	TS-1	16 × 8	7.5	18	10	1	+
5	13/F	−	−	Acinic cell	R	pT2N2bM0	—	—	7.5 × 4	8	12.5	10	1	+
6	34/M	−	−	Adenocarcinoma	L	pT4aN1M0	60 Gy	—	9 × 4.5	8	9	7	1	+
7	41/M	−	−	Acinic cell	L	pT2N2bM0	60 Gy	—	6.5 × 4.5	10	15	12	2	+

Chemo, chemotherapy; F, female; FVL-FMTt, free vastus lateralis functional muscle transfer type; L, left; M, male; NG, nerve gap; NGL, nerve graft length harvested; R, right; Tob, tobacco history; TS-1, oral antitumor agent (tegafur/gimeracil, oteracil); Vasc, vascular history.

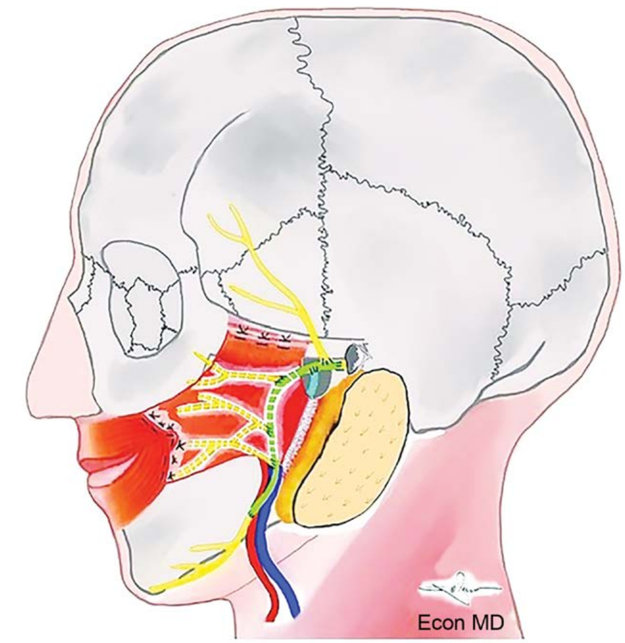

Fig. 4. Schematic depiction of the flap inset procedure, including the functional muscle attachment and nerve coaptations in both types of FVL-FMT.

Surgical Technique

After performing a radical parotidectomy and neck dissection, the branches of the facial nerve were identified using intraoperative neuromonitoring stimulation (NIM 3.0, Medtronic, MN). Doppler studies guided flap markings to identify perforators, which were then harvested using the vastus lateralis (VL) myocutaneous flap technique.[9] The length of the vascular pedicle was adjusted by dissecting its distal course into the muscle and then dissecting its proximal course as it originates from the LCF artery. The functionality of the VL muscle was verified by inducing contraction through NIM stimulation. The length of the muscle segment was determined by measuring the distance between the tragus and the angle of the mouth. The VL muscle was resected distal to the NVP insertion with Linear Cutters (ETHICON, NJ).

The muscle was contoured during the procedure, and a 3-cm mid-vertical incision was created distally to create a superior and inferior tongue. This was tunneled toward the oral commissure and sutured to the modiolus and upper and lower orbicularis oris through an incision along the nasolabial crease. The proximal aspect of the muscle was placed on tension and anchored subperiosteally to the zygoma to obtain moderate overcorrection of the smile (Fig. 4). After completing the microvascular anastomosis, the db-VLMN was trimmed to the desired length, and the proximal stump of the facial nerve at the pes anserinus and the marginal mandibular branch were coapted with the proximal and distal ends of the db-VLMN by ETE epineural suturing. ETS perineurotomy coaptation of the db-VLMN to the rest of the facial nerve branches and ob-VLMN (in type 2) was done. Finally, the skin was inset

Table 2. Facial Nerve Recovery Assessment

Patient No.	FU (mo)	Pre-YS		Post-YS		Pre-HB	Post-HB_2 Score						
							Brow	Eye	NLF	Oral	SS	Total	Grade
1	15	(4444444444)	40	(2002202222)	16	I	VI	III	III	III	1	16	IV
2	51	(4444444444)	40	(2022420200)	14	I	VI	III	VI	V	1	19	IV
3	78	(0002200000)	4	(0000200020)	4	V	VI	V	VI	V	1	23	V
4	18	(4444442222)	32	(2022220200)	12	II	VI	III	VI	V	1	21	V
5	64	(4444444444)	40	(2044442222)	26	I	VI	I	III	III	1	14	III
6	53	(0002020020)	6	(4044444240)	30	V	VI	I	III	III	1	14	III
7	16	(4444444444)	40	(4044442420)	28	I	VI	I	III	III	1	14	III

FU, follow-up; HB, House–Brackmann score; NLF, nasolabial fold; post, postoperative; pre, preoperative; SS, synkinesis score.

to the cutaneous defect or deepithelialized if less skin was required.

RESULTS

Six patients underwent reconstruction with type 1 and 1 with type 2 FVL-FMT. The follow-up period lasted an average of 41 months, from 12 to 78 months. The smallest flap size was 6.5 × 4.5 cm, whereas the largest flap size was 16 × 8 cm. The mean length of the harvested VL muscle was 8.5 cm, ranging from 7.5 to 10 cm. The mean length of the nerve graft harvested was 13.8 cm, ranging from 9.3 to 17.8 cm, and the mean nerve gap was 8.6 cm, ranging from 5.8 to 12.1 cm. All flaps ultimately survived without complications. No patients experienced any issues with feeding immediately after surgery or during follow-up. Only 1 patient (no. 7) experienced temporary weakness on the donor leg extension, which resolved after a year.

First, facial muscle recovery was observed in the orbital musculature, with 6 cases demonstrating active eye movements within 4 months of treatment. Patients 2, 3, 5, and 7 also showed active eye movements within 1 week of treatment. Between 3 and 9 months after treatment, 5 of 7 (71%) patients showed activation of the lower midface (cheeks and mouth). Within 3 to 6 months after treatment, 57% of cases had mass facial movements.

After reviewing the YS and HB_2 regional scores, it was found that all patients showed no forehead movements, 3 patients had normal eye movements, 3 patients had moderate dysfunction (III) in eye movements, and 4 patients had moderate dysfunction (III) in the regional nasolabial fold and oral scores. At the final follow-up, the HB_2 scores were III (n = 3, 42.9%), IV (n = 2, 28.6%), and V (n = 2, 28.6%), whereas the YS scores ranged from 4 to 30. All patients had minimal synkinesis, and 6 (86%) achieved acceptable symmetrical resting tone. The facial nerve recovery assessment of each patient at the last follow-up is reported in Table 2.

Case Reports

Case 1

A 34-year-old man diagnosed with adenocarcinoma stage IVA (T4aN1M0) presented with a left preauricular mass and facial palsy with an HB_2 of III and YS score of 6 of 40 (0002020020). He had gross facial asymmetry at rest, incomplete eye closure, slight upper and lower lip movement on nose wrinkling, and grinning maneuvers. He underwent radical parotidectomy because of the presence of perineural invasion and type 1 FVL-FMT reconstruction. A composite flap of a 9 × 4 cm skin paddle, VLMN length of 9 cm, and VL muscle length of 8 cm were harvested. A 7-cm vascularized db-VLMN was used to reconnect the facial nerve to its divisions. Microvascular anastomosis was performed on the left external carotid artery and common facial vein. The flap ischemia time was 2 hours, and the total operation time was 11 hours and 23 minutes.

Active eye movements were observed at 3 weeks postoperation. (**See Video 1 [online]**, which displays a patient [case 1] showing facial maneuvers with active eye closure 3 weeks after FVL-FMT type 2 reconstruction.)

The YS score 1 month postsurgery was 10 of 40 (4022200000), with facial symmetry at rest and active eye movements achieving partial eye closure, but the lower midface was paralyzed (Fig. 5). Despite the paralysis, no feeding difficulties were reported on follow-ups. In the third month, the patient underwent RT with a 60 Gy dose for 6 weeks. In the sixth month, weak movements of the lips and cheek were reported with YS of 14 of 40 (4022222000). On the 10th month, improvement of the lower midface showed a YS score of 20 of 40 (4042204220) with partial active movement of lips, corner of the mouth, and cheeks while attempting to grin and whistle. After two years, the improvement of YS reached a score of 28 out of 40 (4044444220) (Fig. 6). (**See Video 2 [online]**, which displays a patient [case 1] showing facial maneuvers 2 years after FVL-FMT type 2 reconstruction.) At the latest follow-up (4½ y), there was a slight improvement with grinning with YS of 30 of 40 (4044444240) and HB_2 of III.

Case 2

A 41-year-old man diagnosed with acinic cell carcinoma stage IVA (T2N2bM0) presented with a left infra-auricular mass and underwent radical parotidectomy and type 2 FVL-FMT reconstruction. For coverage, a skin paddle measuring 6.5 × 4.5 cm was incorporated during the flap harvest. The myocutaneous perforators identified originated from the oblique branch of the LCF. A 12 cm length of db-VLMN was utilized to reconstruct the facial nerve. Likewise, the ob-VLMN was also anastomosed to db-VLMN. Microvascular anastomosis was performed on the left external carotid artery and internal jugular vein.

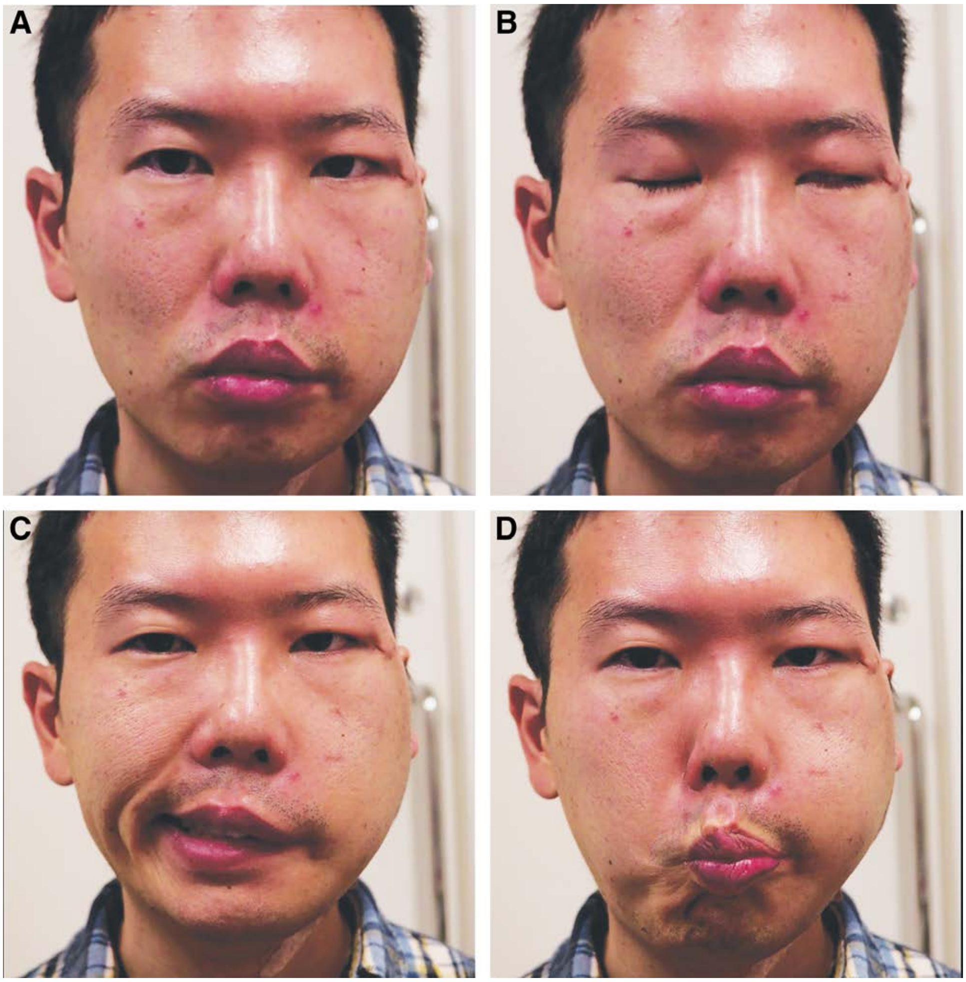

Fig. 5. Photographs of patient in case 1 doing facial maneuvers with resting symmetry and good tone (A), light eye closure (B), smiling (C), and whistling at 3 weeks postsurgery (D).

The patient had symmetrical resting tone, partial closure on the left eye when blinking, and light closure 3 days postsurgery (Fig. 7). (**See Video 3 [online]**, which displays a patient [case 2] showing active eye closure 3 days after FVL-FMT type 1 reconstruction.) A month later, he had active eye movements on blinking, light, and tight eye closure maneuvers. In the third month, the patient underwent RT with a 60 Gy dose for 6 weeks duration. In the fourth month, the patient had complete eye closure with minimal effort and perceptible malar movement with slight synkinesis when grinning. Their last follow-up on the 14th month showed a YS of 28 of 40 and HB_2 of III before they died due to complications from cancer (Fig. 8).

DISCUSSION

In parotid malignancy, surgeons face challenges in reconstructing nerve gaps and soft tissue defects, particularly due to radiation and fibrosis. Research shows that the best time for nerve repairs is 4–5 hours after injury, before Wallerian axonal degeneration begins.[10–12] If left untreated, facial palsy can lead to significant functional and psychosocial issues, mainly from denervation of the orbicularis oculi and lower lip depressor muscles. Therefore, facial reanimation should focus on these muscles to improve quality of life,[6] with immediate, single-stage reconstruction being ideal for optimal recovery.

There are different techniques described in the literature for facial nerve reanimation. Nonvascularized nerve grafts have shown promising results in repairing nerves, with House–Brackmann scores of II (n = 3, 14%), III (n = 8, 36%), IV (n = 7, 32%), and V (n = 4, 18%) after an 8-month follow-up.[13] Masseteric nerve transfer techniques can power gracilis muscle transfers and directly connect to the facial nerve for reanimation. This technique is popular due to its ease of dissection, proximity to the facial nerve, and low morbidity, with favorable results in both the time to nerve recovery (averaging 5 mo, with a range of 2–7 mo) and improvement in symmetrical smile excursion (with a 5 mm difference between the normal and paralyzed sides).[14,15] Nonvascularized grafts and nerve transfers are only suitable for short nerve gaps. Interposition nerve grafts can be utilized in masseteric nerve transfers to extend the length of the nerve. However, this method may lead to delayed recovery times, although the impact

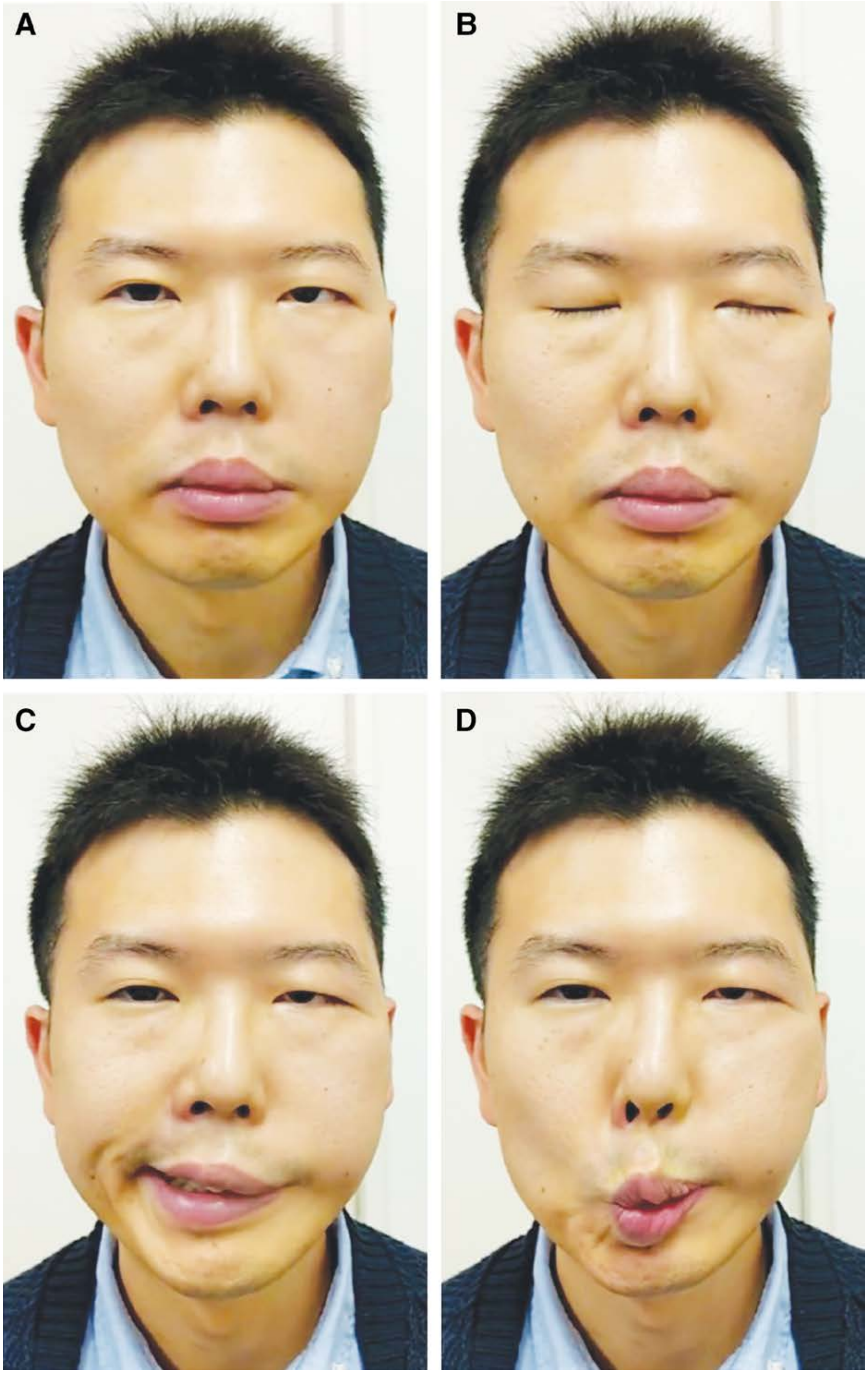

Fig. 6. Photographs of patient in case 1 doing facial maneuvers with resting symmetry and good tone (A), light eye closure (B), smiling (C), and whistling at 2 years postsurgery (D).

is insignificant.[14] Patients with longer nerve gaps and multiple coaptations may encounter more significant recovery challenges. Thus, this technique may not be ideal for our patients.

For radical parotidectomy defects, Bedarida et al[2] reported the use of an adipocutaneous, vascularized thoracodorsal nerve flap in patients with stage IV parotid cancer; their House–Brackmann scores were III (n = 3, 25%) and IV (n = 6, 75%) after an average follow-up of 30.8 months.[2] Our flap's advantage is incorporating the VL muscle, which can provide a more significant tissue bulk for contour restorations. For functional muscle transfer and reanimation of the lower midface, the gracilis free flap has been a mainstay choice because of its excellent results, reliability, and low donor site morbidity.[15] The FVL-FMT can be a good alternative in cases where the gracilis flap

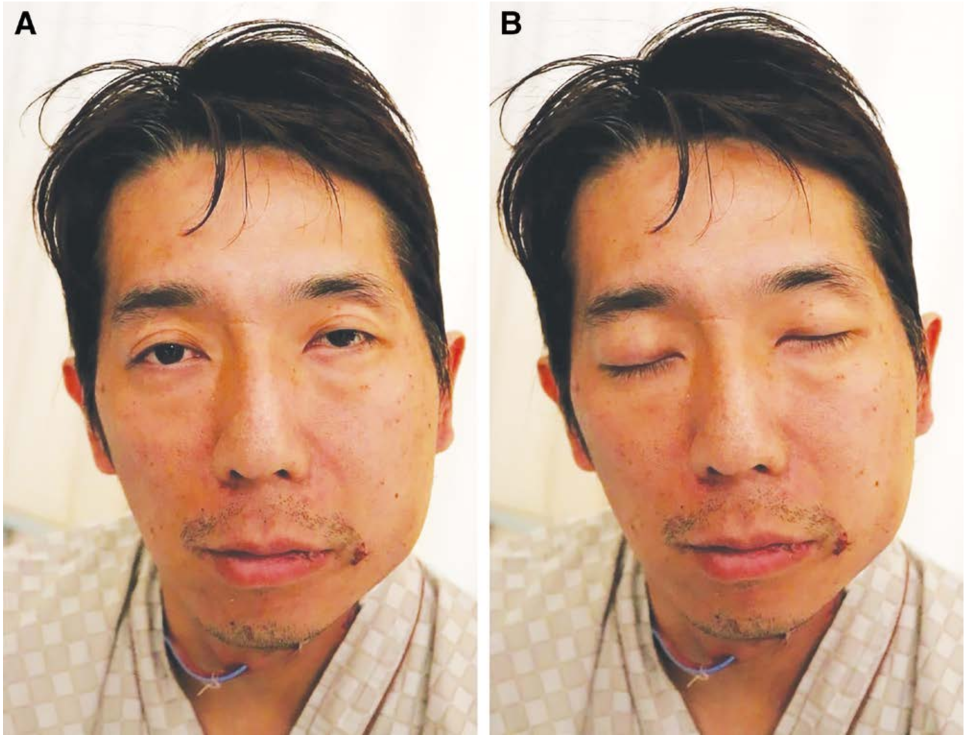

Fig. 7. Photographs of patient in case 2 who achieved symmetrical resting tone, good aesthetic bulk (A), and active eye closure 3 days after surgery (B).

is recommended or in situations involving extensive resection of large tumors requiring a bulkier musculocutaneous coverage or a longer nerve graft for multiple nerve coaptations.

Few literature reports describe using vascularized VLMN for repairing nerve gaps or using VL as a free muscle transfer for facial reanimation. However, this article is unique because it is the only case series that describes the use of db-VLMN for reconstructing the facial nerve from the pes anserinus to its various branches using a series of ETE and ETS perineurotomy coaptations.

The decision to use type 1 or 2 FVL-FMT depends on flap anatomy determined through ultrasound-guided identification of perforators and intraoperative location of perforator branches, vessels, and nerve graft length. In case 2, musculocutaneous perforators originated from the oblique branch of the LCF. Therefore, the neuromuscular component of the VL innervated by the ob-VLMN was harvested. If only functional muscle transfer is needed, either type can be used. However, type 1 is preferred because of db-VLMN's constant location, longer length (15.2 ± 3.4 cm), and vascular pedicle (9 ± 0.4 cm), along with numerous axons (1158 ± 378) over the ob-VLMN.[16,17] It is a vascularized motor nerve with a harvestable graft length of more than 6 cm, which makes it a suitable facial nerve graft for patients. It overcomes delays in perfusion in conditions of fibrosis and irradiation[1,3–6,17] and yields better regeneration than mixed or sensory donor nerve grafts.[1,4,6,18,19]

Although several reanimation techniques have been developed for facial nerve regeneration, the success rate varies. Age is an important factor affecting the outcomes of facial nerve reanimation, as older patients tend to show poor nerve recovery due to changes in nerve morphology, electrophysiological function, and decreased axonal load.[20–22] Our cohort showed such a pattern that patients in their 60s and 70s had the poorest outcomes, regardless of their prior facial nerve status. However, the VL muscle helped provide soft tissue bulk, symmetrical resting tone, and oral competence during nerve regeneration, even in older patients with suboptimal outcomes.

The success of facial reanimation procedures can be affected by the mismatch between the donor nerve's axon count (say, the facial nerve with a mean of 5329 ± 1376 axons), the capacity of the nerve graft (such as the thoracodorsal nerve with 2789 ± 707 axons, obturator nerve with 818 ± 116, and the db-VLMN with 1158 ± 378), and the axon requirements of the recipient nerve (such as the buccal branch, which needs an average of 1673 ± 973 axons).[17,20] No nerve graft can fully replicate the native facial nerve's complexities and axonal count. To ensure the successful restoration of facial muscle function, the donor nerve must regenerate and reinnervate the same number of axons as the recipient nerve.[23] Failure to do so can result in incomplete and impaired recovery. However, only 50% of axons regenerate at each coaptation site, and this percentage decreases to 25% with a nerve graft bearing 2 sites.[24] In the future, intraoperative axon quantification tests could help determine donor suitability and recipient axon requirements.[25]

Our series of patients experienced moderate lower midface function and no movement in their forehead.

Fig. 8. Photographs of patient in case 2 doing facial maneuvers with resting symmetry and good tone (A), light eye closure (B), whistling (C), and grinning at 1 year postsurgery (D).

To enhance the outcomes of our nerve graft, we suggest performing nerve transfer techniques simultaneously with our flap. This will help to recruit supplementary donor nerve axons from the hypoglossal and masseteric nerves, which can supercharge the nerve graft and improve the function of the facial nerve's temporal-zygomatic and bucco-marginal divisions.

The impact of RT on facial reanimation outcomes is complex and requires further study. Some research shows no significant differences between radiated and nonirradiated groups,[26–28] whereas others indicate that RT after nerve grafting may delay healing and nerve regeneration, and lead to poor outcomes.[5,26,27] It can also cause skin contracture, increase fibrosis, and reduce muscle viability, potentially hindering the effectiveness of free muscle transfer and the success of facial reanimation techniques.

The effectiveness of this technique may have yet to be fully captured due to the limitations of our study. For instance, the population was small, and the study was conducted retrospectively. Additionally, the grading system was not explicitly designed to evaluate facial nerve function after postsurgical resection, as HB_2 and YG scores were initially meant for other purposes.[7,8] Therefore, further research with a larger sample size and more appropriate evaluation tools is needed to fully understand this technique's impact.

Early active eye movements after surgery slowed significantly within a week but improved over time. We could not assess complete paralysis postdischarge because follow-ups occurred a month later, and some patients delayed them due to long travel distances.

We believe that immediate reanimation prevents or delays axonal degeneration[9–11] and allows small amounts of neural stimuli to pass through the reconstructed nerve, helping to maintain orbicularis muscle function and preventing atrophy. Grace et al[29] found that immediate nerve repair in rabbits restored conduction velocity to 63% of pretransection levels, indicating that impulses can "jump" across the microanastomosis and trigger a neuromuscular response. However, conduction decreases after 7 days due to Wallerian degeneration in the distal nerve.[29]

Despite the study limitations, our observations suggest that our facial reanimation technique can prevent eye complications, maintain oral competency, and improve psychosocial wellness by achieving an acceptable smile and facial symmetry in patients with postsurgical facial palsies.

In general, the flap technique has shown promising results as all patients achieved active eye movements, whether wholly or partially closed (HB_2 I and II), and most achieved partial lower midface functions (HB_2 III) at the time of their last follow-up. Additionally, the procedure was found to be reliable with no complications during recovery and remained resilient even during periods of RT. Although our case series did not observe any significant muscle dysfunction at the donor site, it is still possible for functional disability to occur in the future. Therefore, functional muscle testing during follow-ups, particularly for type 2 FVL-FMT,[16] is highly recommended.

CONCLUSIONS

Patients who develop facial palsy after surgery can significantly improve their quality of life through immediate facial nerve reconstruction. The FVL-FMT is an effective and reliable single-stage flap method that can restore function and aesthetic appearance in complex facial nerve defects.

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DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

PATIENT CONSENT

Patients provided written consent for the use of their images.

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