Functioning Free Gracilis Myocutaneous Flap Transfer Provides a Reliable Single-Stage Facial Reconstruction and Reanimation following Tumor Ablation

Chih-Hung Lin, M.D.
Christopher Wallace, M.D.
Chun-Ta Liao, M.D.

Taoyuan, Taiwan

Background: Ablative orofacial defects incorporating mimetic facial musculature/nerve cause hemifacial expressive dysfunction and considerable morbidity but are rarely reanimated immediately using free functioning gracilis myocutaneous flaps.

Methods: Disrupted buccal branches provided a recipient facial nerve for 24 gracilis reinnervations. An additional 15 free flaps were used for extensive composite defects. Smile outcome was graded according to Terzis' criteria after 2 years of recurrence-free follow-up. The effects of postoperative radiotherapy, integrity of the oral commissure, and double free flaps were compared.

Results: Eighteen patients completed 2 years' recurrence-free follow-up; average smile outcome was Terzis grade 4 (mean, 3.8). Resection/reconstruction of the modiolus (five of 18 patients) tended to diminish outcome (Terzis grade 3, mean, 3.0; median, 3; versus Terzis grade 4, mean, 4.1; median, 5) compared with two free flaps performed simultaneouly (mean, 3.56 versus 4.14; median, 3 versus 5). Postoperative radiotherapy (eight of 18 patients) had a more modest effect on outcome (Terzis grade 3, mean, 3.3; Terzis grade 4, mean, 4.1; median, 3 versus 5).

Conclusion: Reconstruction of oncologic defects including expressive facial musculature/nerve with gracilis free functioning muscle transfer can restore oral continence and facial expression primarily. (*Plast. Reconstr. Surg.* 128: 687, 2011.)

CLINICAL QUESTION/LEVEL OF EVIDENCE: Therapeutic, IV.

Inadequately treated or untreated facial paralysis can have serious functional, expressive, aesthetic, and psychosocial consequences for affected individuals.[1] Facial paralysis usually presents as an isolated problem that requires only facial reanimation. However, wide excisions of intraoral/facial tumors occasionally cause concomitant regional facial expression disability from resection of mimetic muscles and/or facial nerve branches.[2,3] For these defects, there is an additional need for a flap that can reconstruct the missing soft tissues, which may include the intraoral mucosa, the facial skin, and/or the intervening cheek tissues, and can provide a functioning muscle to reanimate the face.

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From the Department of Plastic and Reconstructive Surgery, Chang Gung Memorial Hospital and Chang Gung University.
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Although the gracilis continues to be the donor site preferred by many authors for free functioning muscle transfer to treat pure facial paralysis in adults,[4–11] to our knowledge, there are no articles in the literature describing *primary* facial reanimation with simultaneous soft-tissue repair using the functioning gracilis myocutaneous free flap. No alternative form of reanimation produces the same quality of mimetic function.[5,6] As such, we looked to perform free functioning muscle transfer at the time of tumor ablation, and have had some reasonable success. We report this technique and its results in a consecutive series of patients.

PATIENTS AND METHODS

Between 2000 and 2007, 24 male patients (mean age, 43 years; range, 28 to 63 years) who underwent gracilis free functioning muscle transfer to reconstruct and reanimate the face immediately following tumor excision in the cheek region were identified prospectively and followed up for at least 2 years postoperatively or until they died. All had planned ablative operations that would include resection of entire buccal musculatures involved in smiling and consequent partial facial paralysis. During preoperative counseling, these motivated patients particularly requested and gave informed consent for primary dynamic facial reanimation in preference to secondary reanimation at a future operation.

The tumors consisted of T2 to T4 lesions. Of these 24 patients, eight required resection of the oral commissure for clearance and 16 had the commissures spared. Fifteen patients with through-and-through composite cheek and oral defects required restoration of oral mucosa by simultaneous fasciocutaneous anterolateral (or anteromedial) thigh free flap ($n = 12$) or fibula osteoseptocutaneous flap ($n = 3$) for segmental mandibulectomy and oral defect, whereas the gracilis skin paddle was used to restore cheek skin loss and the free functioning muscle transfer was used for cheek volume and reanimation. Nine patients required a single gracilis free functioning muscle transfer for oral mucosal defect resurfacing and facial reanimation.

Operative Methods

Branches of the facial nerve were identified and their end-muscular function(s) delineated by electrical stimulation to safeguard the functioning branches that oncologically could be preserved. Nerve stimulation was applied on the grossly intact remaining facial nerve, and the cases of evocable commissural contraction were excluded for facial muscle reanimation. The disrupted nerve stumps were marked with epineural sutures left long. The gracilis free functioning muscle transfer was harvested essentially as described previously.[2,7,12]

The inset of flaps started intraorally, progressing toward facial skin. Thus, in patients with through-and-through cheek resections, the intraoral defect was resurfaced with an accompanying free flap (anterolateral thigh, anteromedial thigh, or fibula flap in this series), followed by gracilis muscle inset and finally gracilis skin paddle for facial skin reconstruction. When there was not a through-and-through defect, the gracilis skin paddle was used to repair the intraoral defect, followed by muscle inset, and finally direct repair of the facial wound.

The proximal gracilis muscle with the obturator nerve was fixed to the native modiolus or presumed reconstructed modiolus, the gracilis muscle tension was set carefully to the planned vector of muscle excursion, and the required length was fixed to the zygomatic arch with several interosseous wires. The remaining distal gracilis muscle was used for filling dead space when present in the retromolar region or maxillary antrum. Then, the cutaneous paddle was rotated and translated accordingly to inset into the intraoral or extraoral defect with special protection of intervening septocutaneous vessels or musculocutaneous perforators arising from the main pedicle. Once the muscle inset was complete, disrupted buccal branches of the facial nerve provided ipsilateral nerve stumps for microneural coaptation to the gracilis motor nerve. Flap revascularizations were performed as end-to-end microvascular anastomoses of one vein and one artery per flap to a branch of the internal/external jugular vein and a branch of the external carotid artery, respectively.

Postoperative adjuvant therapy, including irradiation with or without chemotherapy, will depend on the pathologic finding discussed at the combined conference of the postoperative multidisciplinary head and neck cancer team, which includes a pathologist; ear, nose, and throat surgeon; oral surgeon; oncologist; radiation oncologist; radiologist; plastic surgeon; and others.

Outcome Assessment

Timing of return of gracilis muscle contraction was assessed at postoperative clinics and smile

was graded independently according to Terzis' Functional and Aesthetic Grading System for Smile at 2 years postoperatively.[13] Fourteen patients required radiotherapy starting 4 to 6 weeks postoperatively, for a mean dose of 60 cGy of gallium. The influence on functional outcomes of either preservation or resection of the native modiolus, and of the presence or absence of postoperative irradiation, was assessed statistically using the Mann-Whitney *U* test. The significance level was set at 0.05.

Six patients were excluded from functional outcome assessment, as they did not complete 2 years of follow-up before sustaining locoregional recurrence requiring ipsilateral or contralateral buccal cancer excision. Eighteen of the 24 patients fulfilled at least 2 years of recurrence-free follow-up and were included in the assessment of functional outcome; one of these died as a result of metastatic disease at 63 months postoperatively but was recurrence-free at 2 years.

RESULTS

All 38 flaps performed in these 24 patients survived; none required reexploration for salvage. One gracilis skin paddle suffered 25 percent loss and required elective revision. Time until first palpable flicker of gracilis muscle movement was noted in all patients at 3 to 4 months postoperatively in the outpatient clinic. Locoregional tumor recurrence or distant metastasis occurred in six patients within 2 years. Eighteen patients survived recurrence-free beyond 2 years and were included for functional assessment (Table 1).

Among these 18 patients, three achieved Terzis grade 2 ("fair"; no symmetry, bulky, minimal contraction), six achieved Terzis grade 3 ("moderate"; moderate symmetry, moderate contraction, mass movement), one achieved Terzis grade 4 ("good"; symmetric nearly full contraction), and eight achieved Terzis grade 5 ("excellent"; symmetrical smile with teeth showing, full contraction) smiles at 2 years.[13] The average outcome was Terzis grade 4 (mean, 3.8; median, 3.5). Patients with Terzis grade 3 (or better) outcomes objectively achieved better control of oral continence and subjectively complained less of salivary drooling, in contrast to patients with Terzis grade 2 outcomes.

The five patients who required oral commissure resection/reconstruction achieved a mean outcome of Terzis grade 3 (mean, 3.0; median, 3). The remaining 13 patients with preserved oral commissures achieved a mean outcome of Terzis grade 4 (mean, 4.1; median, 5). Although this difference appeared clinically significant, patient numbers were insufficient to demonstrate a statistically significant difference ($p = 0.091$; $Z = -1.688$).

It has been reported that radiotherapy may adversely affect nerve regeneration, although this remains controversial.[14] Eight patients who required postoperative radiotherapy presented a mean outcome of Terzis grade 3 (mean, 3.3; median, 3), whereas patients who did not require postoperative radiotherapy achieved a mean outcome of Terzis grade 4 (mean, 4.1; median, 5). Statistically, this was not significantly different ($p = 0.235$; $Z = -1.189$).

Seven patients underwent single gracilis flap for oral defect and reanimation and presented a score of 4.14 (median, 5). The other 11 double free flap patients (with accompanying anterolateral thigh, anteromedial thigh, or fibular flap) presented a score of 3.56 (median, 3) ($p = 0.257$; $Z = -1.079$), which demonstrated no statistically significant difference.

CASE REPORTS

Case 17

A 63-year-old man with a T2N0M0 right buccal cancer underwent tumor ablation, including resection of the buccal musculature, and lost evocable nasolabial contraction (Fig. 1, *left*). The modiolus was preserved. Reconstruction involved a gracilis free functioning muscle transfer (to repair the intraoral and functional defects as described). The patient did not receive postoperative radiotherapy. Contraction of the transferred gracilis was noticed 6 months postoperatively, and he achieved good contraction by 1 year. At 2 years, this patient had achieved a Terzis grade 5 outcome (Fig. 1, *below*). (**See Video, Supplemental Digital Content 1,** which shows the patient in case 17, a 63-year-old man who underwent left gracilis muscle flap for right facial reanimation and who presented a symmetric smile with upper teeth showing 5 years after reconstruction, ***http://links.lww.com/PRS/A371***.)

Case 24

A 40-year-old man sustained a through-and-through left orofacial defect from ablation of a T2N0M0 tumor (Fig. 2, *above, left*). He underwent a free left anterolateral thigh flap to reconstruct the oral defect and a gracilis free functioning muscle transfer for left facial reanimation and facial skin reconstruction (Fig. 2, *center, left*). The gracilis motor nerve was coapted to the zygomatic and buccal branch stumps of the facial nerve (Fig. 2, *above, right*). Postoperative radiotherapy was not required. Some return of gracilis contraction was visible by 6 months (Fig. 2, *center, right*), and a symmetric smile was achieved by 1 year postoperatively. At 2 years, this patient had achieved a Terzis grade 5 outcome (Fig. 2, *below*). (**See Video, Supplemental Digital Content 2,** which shows the patient in case 24, a 40-year-old man who sustained a through-and-through left orofacial defect and underwent left gracilis muscle flap surgery, ***http://links.lww.com/PRS/A372***; he presented with symmetric smile with upper teeth showing 6 years after reconstruction.)

Table 1. Demographic and Postoperative Variables of the Patients by Sequence

Patient	Age (yr)	Clinical Staging	Pathologic Staging	Defect Size	Lip Defect	Flap	Irradiation	Terzis Grading	Follow-Up (mo)	Morbidities
1	38	T3N1M0	T4N1M0	TT, MM, IM	Right 1/4	Gracilis and AMT	R/T	2	63	Infection, metastasis dead 4 yr
2	53	T4N0M0	T4N0M0	TT, SM	Right lower lip 1/5	Gracilis and fibula	R/T	3	74	
3	45	T4N0M0	T4N0M0	MM	Left 1/5	Gracilis	R/T		71	Recurrence 9 mo
4	47	T1N0M0	T3N0M0	Oral side	Left 1/4	Gracilis	No	3	70	
5	28	T3N0M0	T3N0M0	MM	Intact	Gracilis	No	4	70	
6	41	T3N2bM0	T3N1M0	TT, MM, IM	Intact	Gracilis and ALT	No*	5	69	
7	54	T4N1M0	T2N1M0	TT, SM	Intact	Gracilis and fibula	R/T	3	69	
8	43	T4N0M0	T4N1M0	TT, MM	Right lower lip 1/4	Gracilis and ALT	R/T		68	Recurrence 3 mo
9	39	T2N0M0	T2N0M0	TT, MM	Intact	Gracilis and ALT	No	5	68	
10	55	T3N2bM0	T3N2bM0	TT, MM, IM	Left 1/5	Gracilis and ALT	R/T	5	67	
11	44	T4N1M0	T4N1M0	TT, MM, IM	Right lower lip 1/4	Gracilis and ALT	R/T		65	Recurrence 16 mo
12	44	T2N2bM0	T2N2bM0	TT, MM	Intact	Gracilis and AMT	R/T	3	61	
13	33	T4N0M0	T4N1M0	TT, MM, IM	Left lower 1/4	Gracilis and ALT	No*	2	59	
14	37	T2N0M0	T2N0M0	MM	Intact	Gracilis	No	2	58	
15	38	T2N1M0	T2N0M0	MM, IM	Intact	Gracilis	No	5	58	
16	37	T2N0M0	T1N0M0	MM, IM	Intact	Gracilis	No	5	55	
17	63	T2N0M0	T2N0M0	MM, IM	Intact	Gracilis	No	5	54	
18	58	T2N0M0	T2N0M0	MM, IM	Intact	Gracilis	R/T	5	54	
19	33	T3N0M0	T3N0M0	MM	Intact	Gracilis and ALT	R/T	3	53	
20	54	T3N0M0	T3N0M0	MM, IM	Intact	Gracilis	CCRT		47	Recurrence 10 mo
21	31	T4N1M0	T4N0M0	TT, SM, IM	Intact	Gracilis and fibula	R/T		47	Recurrence 14 mo
22	40	T2N0M0	T2N0M0	TT, MM, IM	Intact	Gracilis and ALT	R/T		46	Recurrence 11 mo
23	52	T2N0M0	T2N0M0	TT, MM, IM	Intact	Gracilis and ALT	R/T	3	37	
24	40	T2N0M0	T2N0M0	TT, MM, IM	Intact	Gracilis and ALT	No	5	32	

TT, through-and-through defect; MM, marginal mandibulectomy; SM; segmental mandibulectomy; IM, inferior maxillectomy; ALT, anterolateral thigh flap; AMT, anteromedial thigh flap; R/T, radiotherapy; CCRT, chemotherapy and radiotherapy.
*Second primary cancer; this patient had undergone radiotherapy before.

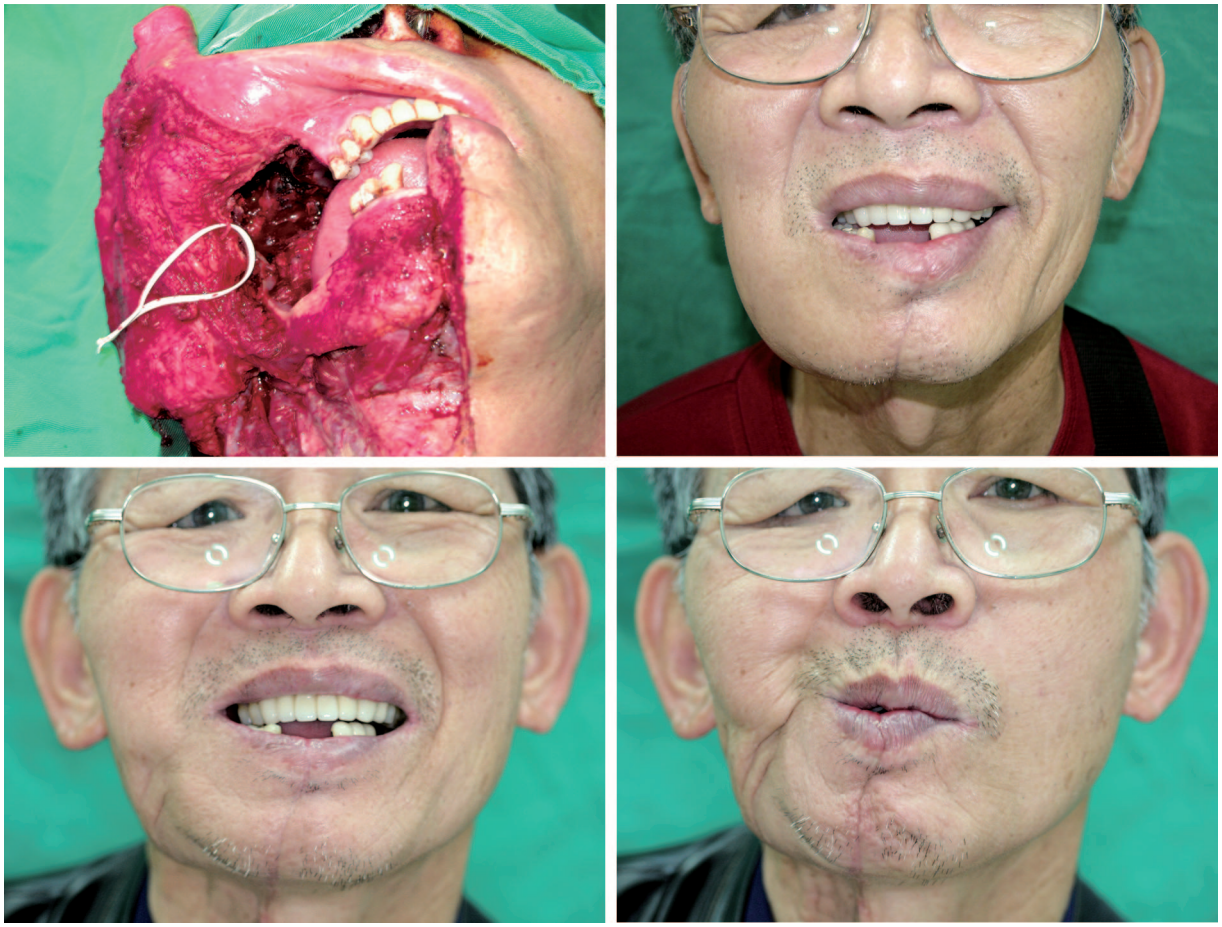

Fig. 1. Defect following resection of a T2 right buccal cancer including both zygomaticus muscles and distal buccal branch of the facial nerve; the proximal facial nerve stump (buccal branch) that will be used to motor the gracilis is indicated (*above*, *left*). Some return of gracilis contraction is visible by 6 months following immediate reanimation/reconstruction with a free functioning gracilis myocutaneous flap (*above*, *right*). Smile outcome (*below*, *left*) and full oral continence are demonstrated at 12 months (*below*, *right*).

DISCUSSION

Buccal cancer resection can cause severe functional and psychosocial debilitation despite reconstruction of soft tissues. This is potentially made worse if concomitant facial expression musculature is excised; this causes not only expressive and aesthetic difficulties but also oral incompetence and salivary drooling if the oral commissure is breached by ablation.[1,5]

It is possible to restore lost mimetic facial movement by nerve coaptation, graft nerve transfer, and regional or free functioning muscle transfer.[5,15,16] For long-standing facial paralysis, a two-stage procedure (cross-facial nerve grafting followed by free functioning muscle transfer) is generally regarded to be the superior reconstruction with a better chance of synchronous, spontaneous, expressive, and symmetric smile.[17] Single-stage free muscle transfers, as recommended by Harii based on the use of latissimus dorsi with a long nerve segment, are an alternative to the classic two-stage reanimation for established facial paralysis.[18] Almost invariably this is performed as a *secondary* reconstructive procedure in patients in whom there is no requirement to reconstruct an additional soft-tissue defect.

Recently, there have been a few single case reports describing *primary* facial reanimation in patients with an additional soft-tissue defect where a single free functioning muscle transfer is used both to replace soft tissue and also to reanimate the face.[19–21] All have described using the latissimus dorsi free functioning muscle transfer. These reports include one reconstruction by Safak and Akyürek of a compound cheek defect with facial paralysis and loss of mimetic muscles caused by close-range shotgun blast trauma.[19] Iwasawa et al. described one Merkel

Video 1. Supplemental Digital Content 1 shows the patient in case 17, a 63-year-old man who underwent left gracilis muscle flap for right facial reanimation and who presented a symmetric smile with upper teeth showing 5 years after reconstruction, ***http://links.lww.com/PRS/A371***.

cell tumor excision from the cheek involving the masseter and part of the zygomaticus major, and the zygomatic, buccal, and marginal mandibular facial nerve branches.[20] Earlier, Kimata et al. described use of a free parascapular cutaneous flap combined with a latissimus dorsi free functioning muscle transfer on a common pedicle to correct a unilateral facial palsy and a neck defect after a radical parotidectomy.[21] Although the latissimus dorsi myocutaneous flap is a reasonable choice of flap with which to achieve reanimation and soft-tissue reconstruction,[22] it is the experience of our department and others that the gracilis muscle is superior to the latissimus dorsi muscle for producing a more adaptive and expressive smile with more controllable excursion.[5,6,17]

A few case reports in the recent literature have reported use of the gracilis muscle flap to reconstruct functioning lip(s) following extirpation.[23–25] These are different from this series of patients for at least three important reasons. First, they required additional flaps/grafts to gain coverage of the transferred gracilis muscle, thereby causing an additional flap/graft donor site, rather than using a single gracilis free functioning muscle transfer. Second, we report simultaneous free cutaneous flaps (such as anterolateral thigh flap) or fibular osteoseptocutaneous flaps for reliable complex reconstruction of composite through-and-through defects. Third, the reconstructive goal in the cases of lip reconstruction was not to reanimate the face for smiling and expression; rather, they aimed to provide a competent oral sphincter.

Our department was among the first to report a series of patients who required simultaneous soft-tissue reconstruction and facial reanimation; this was achieved using the gracilis free functioning muscle transfer as part of a classic two-stage reconstruction.[2] In all eight patients, facial paralysis was well established, but they had additional defects requiring soft-tissue reconstruction. These consisted of one intraoral, four infraauricular, one temporal, and two auricular defects.[2] All had satisfactory restoration of smile and correction of soft tissues.

We now report for the first time the use of the gracilis free functioning muscle transfer for facial reanimation and contiguous soft-tissue defect reconstruction *immediately* after tumor resection. In all 24 consecutive patients, buccal musculatures and nerves of facial expression were extirpated and the intraoperative evocable commissural contraction was gone and they had additional oral and/or facial defects requiring soft-tissue reconstruction. We demonstrate that Terzis grade 5 ("excellent") results can be achieved by this method in approximately 44 percent (eight of 18) of recurrence-free patients at 2 years postoperatively. In addition, most of our patients reported freedom from salivary drooling, which is a troublesome and common sequela of static facial reconstructions in this region following tumor ablation.

There are perhaps two reasons why this method of treatment has not been described before. First, although use of the gracilis muscle free flap has gained wide popularity because of its predictable vascular anatomy and minimal donor-site morbidity, the gracilis free functioning muscle transfer has been disfavored because of previously reported unreliability of the overlying skin island.[26–28] Although this remains controversial, our department and others have helped dispel this belief with large series of vertically oriented gracilis flap skin paddles used for various indications with high success rates.[6,12,29,30] More recently, several case series of gracilis flaps with transverse skin paddles have been used with high success rates for breast reconstruction.[30–32] Despite these reports, many surgeons prefer instead to transfer the free gracilis muscle and cover it with a skin graft. The use of a skin graft means this would be a poor option for head and neck reconstruction be-

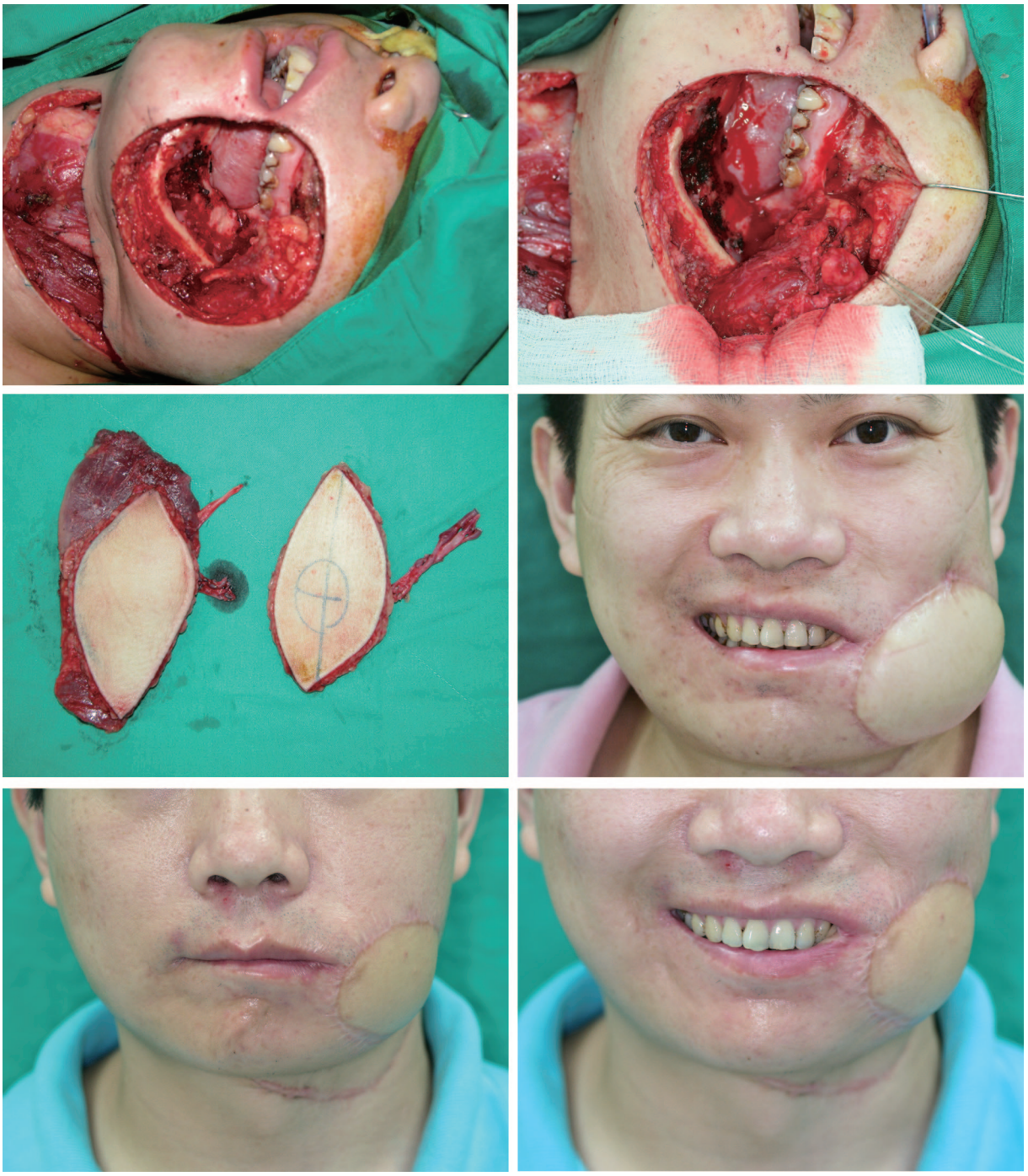

Fig. 2. Extensive through-and-through cheek defect with marginal mandibulectomy following T2 tumor ablation (*above*, *left*). Interosseous wires were placed in the zygomatic arch to provide proximal fixation of the gracilis muscle (*above*, *right*). A fasciocutaneous anterolateral thigh flap was used for intraoral lining and a functioning gracilis myocutaneous flap was used for facial skin reconstruction plus immediate reanimation (*center*, *left*). Some return of gracilis contraction is visible by 6 months (*center*, *right*). Full oral continence and static/dynamic smile are demonstrated at 2 years (*below*).

cause of the disfigured appearance and the possible postoperative radiotherapy.

Second, some patients with oral/facial tumors require high-dose radiotherapy, which is traditionally believed to be detrimental to nerve regeneration and thus may be another reason why free functioning muscle transfer has been avoided after head and neck tumor ablation

Video 2. Supplemental Digital Content 2 demonstrates the patient in case 24, a 40-year-old man who sustained a through-and-through left orofacial defect and underwent left gracilis muscle flap surgery, ***http://links.lww.com/PRS/A372***. He presented with symmetric smile with upper teeth showing 6 years after reconstruction.

reconstruction.[14,33,34] Some authors believe that radiotherapy is so detrimental to the outcome of facial nerve grafting that it should be avoided completely in patients who will undergo radiotherapy, with dynamic or static slings performed instead.[34] Similarly, in a series of 10 patients who underwent gracilis myocutaneous free flap transfer for head and neck reconstruction, none were used as functioning flaps even though at least one patient was described as having a facial nerve deficit.[29] Although the authors commented that patients with sacrificed facial mimetic muscles might benefit from gracilis free functioning muscle transfer, they had not pursued this option in their patients. They did not elaborate on their reasons for this, but it may have been because nine of their 10 patients also required radiotherapy.

The requirement for postoperative adjuvant radiotherapy depends on the pathologic status of the tumor evaluated in a routine tumor conference. Because radiation has been reported to interfere with nerve regeneration and may also cause fibrosis of the muscle flap, it is a possible explanation for the reduction in mean functional outcome in irradiated (Terzis grade 3, mean, 3.3; median, 3) versus nonirradiated (Terzis grade 4, mean, 4.1; median, 5) patients. Despite irradiation, however, two of these eight patients achieved Terzis grade 5 and five achieved Terzis grade 3 smile outcomes. Retrospectively, we do not consider postoperative radiotherapy to be a contraindication to this method of reconstruction. This echoes the experimental and clinical findings of others who have demonstrated little, if any, correlation between irradiation and nerve graft failure/dysfunction.[14,35,36]

Our clinical observation was that the integrity of the mouth angle may have played a more important role in the functional outcome. The tissues at the native modiolus are more elastic than those of a reconstructed oral commissure provided by the skin paddle of free flap that is intrinsically less flexible and possibly more susceptible to tethering from scarring within the lip. Our observations were that when the modiolus was preserved, the functional result was better and more predictable. More recently, therefore, our preference has been not to use this reconstructive method when the modiolus is resected.

Presuming that double free flaps can have more tissue fibrosis and the transferred skin less elasticity, and loss of the integrity of normal facial skin, a single flap presented a better result than a double flap for a through-and-through defect. Regarding that there were no statistically significant differences in the consideration of irradiation, oral commissure, and double free flap, gracilis free functioning muscle transfer provides a predictable functional result for immediate facial reanimation after tumor ablation.

CONCLUSIONS

Reconstruction of complex oncologic defects including mimetic facial musculature with gracilis free functioning muscle transfer can aid restoration of smile, expression, and oral continence, thereby offering improved chances of psychosocial reintegration in select motivated patients. Our clinical observations have led us to avoid using this reconstruction when the modiolus is resected. However, this method can still be used in patients who require postoperative radiotherapy, albeit with a possibly slightly increased risk of reduced functional return. Despite the difference in the outcomes of irradiation, commissural integrity, and simultaneous double free flap, it turns out that gracilis free functioning muscle transfer is a reliable option for achieving both primary facial reanimation and soft-tissue reconstruction in a single stage after the ablative operation.

CODING PERSPECTIVE

This information prepared by Dr. Raymond Janevicius is intended to provide coding guidance.

15842	Graft for facial nerve paralysis; free muscle flap by microsurgical technique

- Code 15842 includes harvest of the free flap, microvascular anastomosis of one artery and two veins, microneurorrhaphy, inset of the flap, and closure of the donor site.
- Although this is a free muscle flap, code 15756 is not appropriate, as it does not include neurorrhaphy or any of the adjustments necessary for facial reanimation. Code 15842 takes these maneuvers into account.
- Code 15842 is a free flap code, so use of the operating microscope is inherent in the code; 69990 is not reported in addition.
- The other two facial reanimation codes, 15840 and 15841, are not free flap codes and would not be appropriate for this procedure.
- When other free flaps are performed in addition to the gracilis free flap for reanimation, they are reported in addition to code 15842, as follows:

15758-59	Anterolateral thigh free flap
15758-59	Anteromedial thigh free flap
20955-59	Free fibula flap

Chih-Hung Lin, M.D.
Department of Plastic and Reconstructive Surgery
Chang Gung Memorial Hospital and Chang Gung University
Taoyuan, Taiwan
chihhung@cgmh.org.tw

PATIENT CONSENT

Patients provided written consent for the use of their images.

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