Simultaneous Reconstruction of the Lower Lip with Gracilis Functioning Free Muscle Transplantation for Facial Reanimation: Comparison of Different Techniques

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Background: Functioning free muscle transplantation is currently the gold standard for the reconstruction of facial paralysis, focusing more on the upper lip reconstruction rather than on the lower lip. This study aimed to compare different lower lip reconstructive methods when performing functioning free muscle transplantation for facial reanimation.

Methods: A retrospective review of functioning free muscle transplantation for facial reanimation from 2007 to 2015 was performed. Patients were divided into three groups: in group 1 ($n = 15$), a free plantaris tendon graft anchored to the gracilis muscle was passed into the lower lip to create a loop within; in group 2 ($n = 12$), an aponeurosis tail of the gracilis muscle was attached to the lower lip; and in group 3 ($n = 18$), no suspension of the lower lip was performed. All patients had at least 2 years of follow-up. Outcomes were assessed by photographs and videos, including subjective evaluation of midline deviation and horizontal tilt and objective analysis of smile dimensions and area.

Results: A total of 45 patients were included. Results from the subjective evaluation demonstrate group 1 patients having the best improvement (overall score: $p = 0.004$ and $p = 0.005$, Fisher's exact test). The objective evaluation showed group 1 and 2 patients with better results compared with group 3 (horizontal component, $p = 0.009$; vertical component, $p = 0.004$; area distribution, $p < 0.001$, Kruskal-Wallis test).

Conclusions: Both plantaris tendon graft and gracilis aponeurosis achieved better improvement in subjective and objective evaluations than those who had no reconstruction of the lower lip. In particular, the plantaris tendon graft can achieve the most lower lip excursion with overall improved symmetry. (*Plast. Reconstr. Surg.* 142: 1307, 2018.)

CLINICAL QUESTION/LEVEL OF EVIDENCE: Therapeutic, III.

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THERAPEUTIC

Functioning free muscle transplantation has become the gold standard of the reconstruction for smile reanimation in facial paralysis patients.[1–10] Functioning free muscle transplantation involves the use of different motor donor nerves such as the cross-face nerve graft (a two-stage procedure),[1,7,9] contralateral facial nerve branches (one-stage procedure),[4] ipsilateral facial nerve branch,[2,5] spinal accessory nerve,[3] masseter nerve,[6,8] hypoglossal nerve,[10] and others.[11] The goals of facial reanimation are to achieve symmetry at rest, and symmetry during dynamic facial expressions without latency and synkinesis. Most efforts at smile reanimation, however, have focused only on the upper lip such as movement of the oral commissure[12,13]

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and appearance of the upper lip, rather than on restoring symmetry of the lower lip, leaving it as a neglected area.[14] This would be a cause for concern in patients that seek to achieve better symmetry and function after surgery. The purpose of this study was to present our patients who underwent simultaneous reconstruction of the lower lip and gracilis functioning free muscle transplantation for smile reanimation, and to analyze the effects on symmetry and function.

PATIENTS AND METHODS

Between the years 1986 and 2015, a total of 362 cases of gracilis functioning free muscle transplantation were performed for facial reanimation. Patients were accrued retrospectively from 2007 to 2015 for collection of more recent and accurately documented data, and a total of 45 patients with chronic complete facial paralysis were enrolled in this study. All functioning free muscle transplantations used the gracilis muscle, and all operations were performed by the same senior surgeon (D.C.C.C.). Exclusion criteria included patients with less than 2 years of follow-up and patients who underwent reconstruction for postparalytic facial synkinesis (17 percent of our 362 cases). They were excluded to avoid confounding factors such as incomplete facial palsy with functional depressors.[15] This study was approved by the Institutional Review Board at Chang Gung Memorial Hospital under the certification number 201701233B0. We have received consent to use and publish the photographs and videos from the enrolled patients.

Patients were divided into three groups based on how the lower lip was addressed. In group 1 (15 patients), a plantaris tendon graft was harvested from the same leg from which the gracilis muscle was harvested. Using a tendon stripper, a plantaris tendon graft of approximately 15 cm was harvested (Fig. 1, *left*). With the gracilis in situ, one end of the tendon graft was sutured onto the lower and medial (vessel-opposed side) edge of the muscle (Fig. 1, *right*). After the gracilis muscle was transferred and inset into the paralyzed face (insertion at the infrazygomatic margin superiorly and the upper lip inferiorly[1]), the other end of the plantaris tendon was threaded through the lower lip through a small incision on the white line of the ipsilateral lower lip. With the help of a nerve passer, the tendon end was passed across the midline of the lower lip to the opposite side through two small incisions on the contralateral lower lip. The tendon was then looped back and exited through the same small incision on the ipsilateral paralyzed lip. The end of the tendon end was sutured onto itself under mild tension (Fig. 2).

In group 2 (12 patients), the proximal gracilis fascial aponeurosis was dissected as high as possible to the origin at the pubic ramus. The whole aponeurosis was tailored by creating a 1-cm-wide tail that was still in continuity with the muscle (Fig. 3). After the muscle was inset, the aponeurosis tail was pulled out through a lower lip incision on the white line of the lower lip vermillion and anchored to the orbicularis oris muscle and surrounding tissue with two or three stitches of 4-0 Vicryl (Ethicon, Inc., Somerville, N.J.). Because of its limited length, this aponeurosis tail did not cross the lower lip midline (Fig. 4). In group 3 (18 patients), there was no lower lip suspension of any form, and the gracilis muscle was anchored only to the upper lip in the same manner as in the other groups (Fig. 5).

Samples of the preoperative and postoperative photographs in the three groups are shown in Figure 6. Patient demographics including age, sex, cause of facial palsy, and donor nerve used for functioning free muscle transplantation are shown and analyzed (Table 1).

Outcome Evaluation

Standardized photographs and videos were taken at each visit in the clinic before and after surgery. Each photograph and video was taken 2 m away from the patient, and the camera lens was set at the height of the nasal tip. Adjustments are made to set the intercanthal line parallel to the horizontal axis of the photograph. All patients in our database were asked to take photographs at "rest status," "smile with ease" that mimics Rubin's classification of commissure smile, and "smile with maximum effort" that tries to expose denture if possible.[16] They were asked to pronounce the |E| sound as in "cheese" to facilitate performance of the smile. Video documentation was used primarily for confirmation of the measurements made from the photographs.

Results were evaluated using subjective and objective approaches. Subjective evaluation consisted of scores given intuitively by reviewers as soon as the photographs and videos were shown. Objective evaluation was measured on photographs in detail based on a concept derived from the scaled measurement of improvement in lip excursion evaluation method reported by Bray et al.[17]

Subjective evaluation was performed by three individuals for better interrater reliability.

Fig. 1. (*Left*) The plantaris tendon is harvested using a tendon stripper. (*Right*) The plantaris tendon is sutured on the medial side of the gracilis muscle.

Outcomes evaluated were as follows. "Midline deviation" was defined as the extent of lower lip midline deviation away from the nasal columella. A score from 1 to 5 was given based on the deviation severity, where 1 was the most severe, with lower lip midline deviation beyond the lateral side of the contralateral nostril; 2 was severe, with midline deviation within the lateral half of the nostril; 3 was moderate, with midline deviation within the medial half of the nostril; 4 was mild, with midline deviation within the columella; and 5, with no deviation (Fig. 7). A score of 1 to 5 was also used to assess the mouth angle "horizontal tilt" using the following method. A horizontal line, defined as the intercanthal line, was compared to the line connecting the two mouth angles, with the difference between these two lines at the ipsilateral commissure recorded and compared to the upper lip height, which is used as the reference (Fig. 7). The most severe was scored as 1, with tilt as defined by the distance between these two lines at the ipsilateral commissure being more than twice the upper lip height; 2 was severe, with the tilt being more than the upper lip height; 3 was moderate, with the tilt less than the upper lip height; 4 was simply a mild tilt; and 5 was no tilt at al. Using these metrics, photographs taken at resting position (static) and at maximum smile excursion (dynamic) before and after surgery (2 years postoperatively) were all evaluated. "Overall score" was defined as the numeric sum of the scores of the above two subjective items.

Fig. 2. Simultaneous lower lip reconstruction with a looped-plantaris tendon graft crossing the midline of the lower lip.

Objective evaluation was examined by smile photographs only.[18] Each photograph was standardized by adjusting the iris diameter value to 11.77 mm as established in previous literature.[19] The midline was defined as the perpendicular bisector of the connection of the two canthi. The iris-scale-corrected horizontal and vertical components of the lower lip excursion before and after surgical intervention were measured by Adobe Photoshop (Adobe Systems, Inc., San Jose, Calif.). Data were tabulated and calculated using Excel spreadsheet software (version 2016; Microsoft Corp., Redmond, Wash.). Besides horizontal and vertical lower lip excursion, "area distribution" was also assessed, as derived from the scaled measurement of improvement in lip excursion evaluation; during full smile excursion, the area of the paralyzed side of lower lip was measured and then calculated as a percentage of the entire lower lip area[20] (Fig. 8).

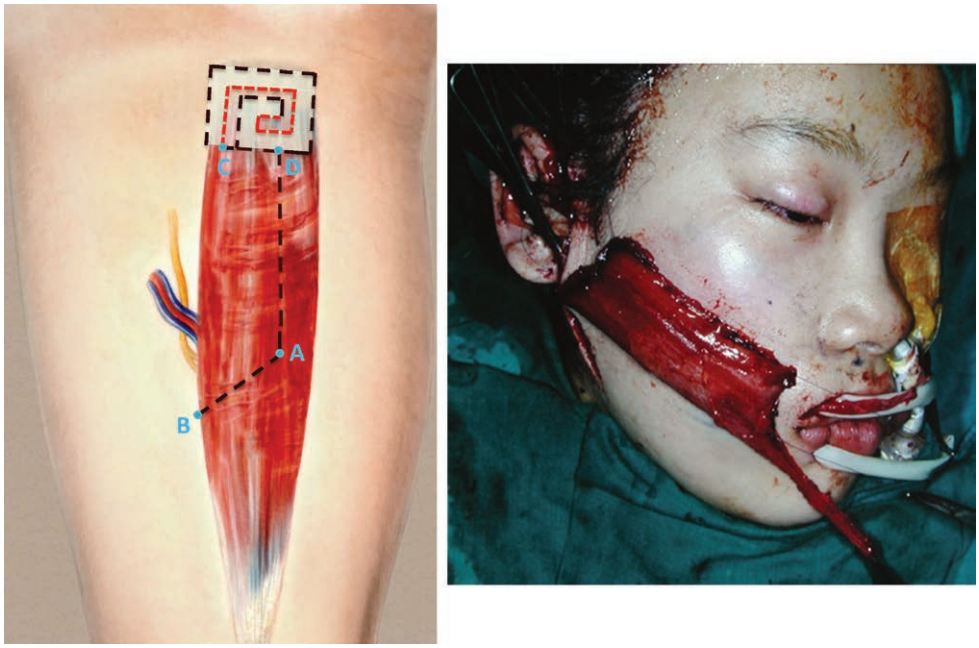

Fig. 3. (*Left*) The gracilis muscle and its aponeurosis tail. (*Right*) The aponeurosis tail is pulled out through an incision wound of the lower lip. (Used with permission from Chuang DCC. Gracilis flap. In: Wei FC, Mardini S, eds. *Flaps and Reconstructive Surgery*. Philadelphia: Saunders Elsevier; 2009:395–409.)

Statistical Analysis

Statistical analysis was completed by using IBM SPSS Version 22.0 (IBM Corp., Armonk, N.Y.). For the subjective evaluation, the Fisher's exact test was used to compare the results among the three groups. Differences among evaluators were assessed using the two-way mixed model to demonstrate whether the measurements changed across patients.[21] For the objective evaluation, the Kruskal-Wallis test was used, because the sample

Fig. 4. The gracilis aponeurosis is sutured to the lower lip without crossing the midline.

Fig. 5. In the third group of patients, the lower lip is not involved in the reconstruction.

Fig. 6. A representative patient was selected from each group, and their before-and-after functioning free muscle transplantation photographs are shown. (*Above*) Group 1, plantaris tendon. (*Center*) Group 2, gracilis aponeurosis. (*Below*) Group 3, not repaired.

size in each group was less than 30. The results of the objective evaluation are expressed as medians and interquartile ranges. Post hoc analysis was performed secondarily using the Dunn test, specifically comparing one group to another if there was a significant difference found among the three groups.[22] A value of $p < 0.05$ was considered statistically significant. A multivariate analysis was not performed because the patient number in each group was not large enough to warrant such a study to derive any significant conclusions.

RESULTS

Subjective Evaluation

The interrater reliability was estimated by an average intraclass correlation coefficient of 0.936,

Table 1. Patient Demographics*

Characteristic	Group 1	Group 2	Group 3	*p*
Total no. of patients	15	12	18	
Age, yr				>0.05
Mean	35	37	27	
Range	6–63	11–55	4–67	
Sex				>0.05
Male	4	4	11	
Female	11	8	7	
Side				
Left	4	4	10	
Right	11	8	8	
Cause				
Bell palsy	5	2	3	
Tumor	10	9	3	
Infection	0	1	3	
Trauma	0	0	2	
Congenital	0	0	6	
Others	0	0	4	
Donor motor nerves				>0.05
CFNG	4	6	6	
XI	9	5	8	
V3	2	1	4	
One-stage donor nerves, %	73	50	67	>0.05

CFNG, cross-face nerve graft; XI, spinal accessory nerve; V3, nerve to masseter muscle.
*Patient characteristics of the three group are listed and analyzed. The distribution of age and gender ratio were analyzed with the Kruskal-Wallis test, and the distribution of neurotizers was analyzed with the χ^2 test.

which was considered acceptable. For static evaluation, group 1 had the best improvement after surgery in midline deviation, horizontal tilt analysis, and the overall score, and these results were statistically significant ($p = 0.0005$ and $p = 0.036$, respectively) (Fig. 9, *above*). For the dynamic evaluation, there was no difference in midline deviation or horizontal tilt ($p = 0.062$ and 0.163, respectively), but the overall score showed a significant difference among the three groups ($p = 0.004$) (Fig. 9. *below*).

Objective Evaluation

A statistical analysis of the objective evaluation verified that group 1 and group 2 had significant differences in lower lip movement compared with group 3 (Fig. 10 and Table 2). Comparing the overall difference among all of the groups, there were significant differences in the three parameters (horizontal component, $p = 0.009$; vertical component, $p = 0.004$; and area distribution, $p < 0.001$). When comparing the groups with each other, group 1 (median, 11.98 mm; interquartile range, 9.67 to 16.92 mm) showed a significant increase in the horizontal component of the lower lip compared with group 3 (median, 7.00 mm; interquartile range, 3.15 to 10.67 mm; $p = 0.008$). The vertical component demonstrated improvement in both lower lip surgical intervention groups, with group 1 (median, 6.65 mm; interquartile range, 4.52 to 9.65 mm) and group 2 (median, 4.88 mm; interquartile range, 3.19 to 9.04 mm) both showing significant differences versus group 3 (median, 2.39 mm; interquartile range, 1.03 to 4.22 mm) (group 1 versus group 3, $p = 0.001$; group 2 versus group 3, $p = 0.039$). Similarly, in the improvement of lower lip area distribution, group 1 (median, 26.78 percent; interquartile range, 21.04 to 29.21 percent) and group 2 (median, 28.64 percent; interquartile range, 15.83 to 33.47 percent) both demonstrated improvements that were significantly better than those in group 3 (median, 7.35 percent; interquartile range, 0.19 to 15.78 percent) (group 1 versus group 3, $p < 0.001$; group 2 versus group 3, $p = 0.001$). However, no significant difference was found between groups 1 and 2 in these three parameters.

DISCUSSION

Lower lip depressor muscles include depressor labii inferioris, depressor angularis, and platysma.[14] The first two muscles evert the vermillion and pull down the lower lip medially and laterally on the mouth angle, helping to show the lower teeth when excursion is strong during smiling. The platysma has a minor influence on lower lip movement, although it can influence the position of the lower lip by means of its muscle resting tone. These depressor muscles have little impact on creating a "joyful" expression with zygomaticus smile (the Mona Lisa smile) and canine smile. Instead, the depressor muscles may generate a snarling expression at maximal contraction, thus creating a "full denture" smile that often seems fake. Most facial paralysis patients request a smile to express pleasure or happiness, but not a full dentured smile. Our goal in facial reanimation is to aim for an attractive natural-appearing smile that is symmetric and acceptable for both the intended target audience and the patient.

Reconstruction of lower lip paralysis is still considered important when a person speaks, although the reconstruction does remain an unsolved problem in facial reanimation. Terzis and Kalantarian described the lower lip as a neglected area of facial reanimation and attempted to address these issues.[14] In their study involving 74 patients, they introduced selective approaches for dynamic reanimation of the lower lip: transfer of the anterior belly of the digastric muscle, transfer of the platysma muscle, using a mini-hypoglossal nerve

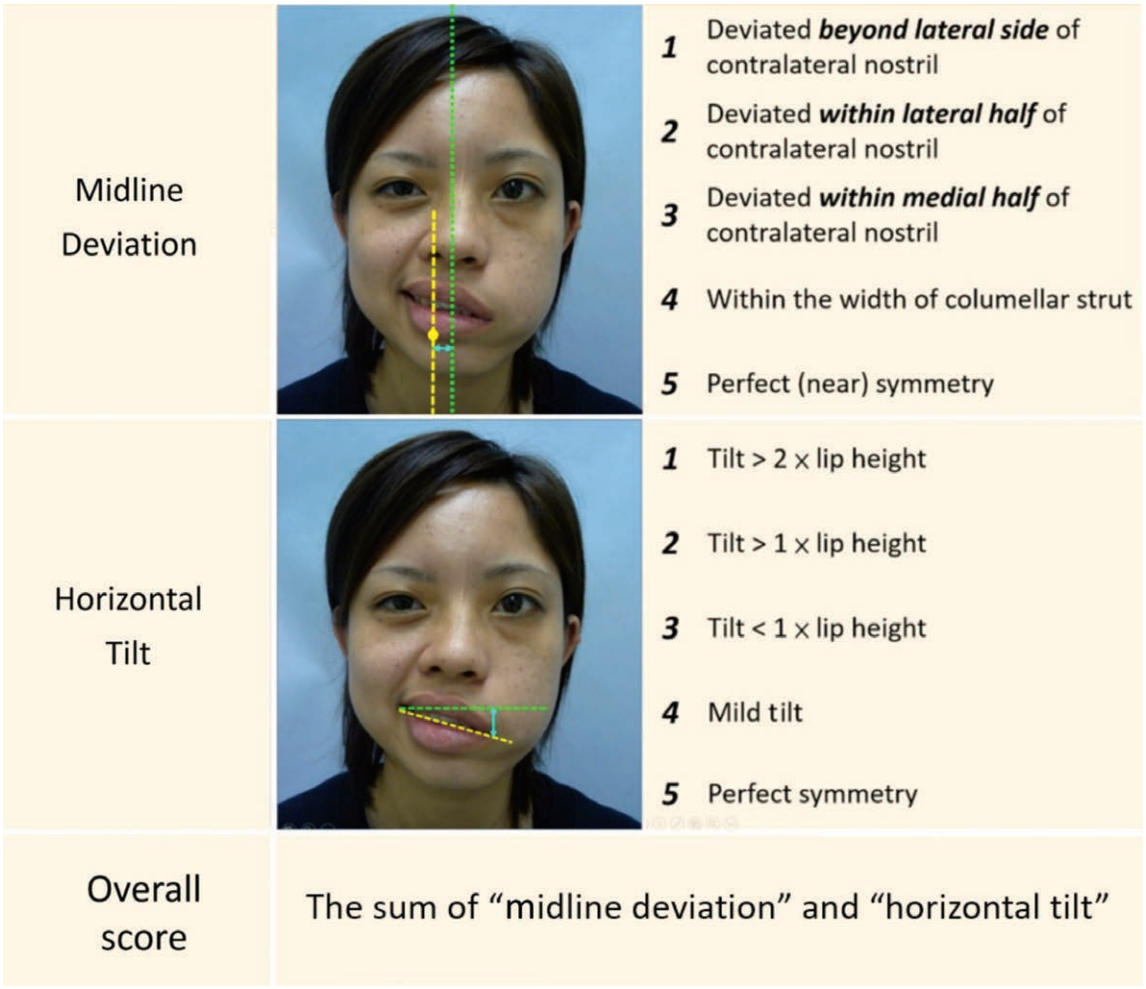

Fig. 7. The subjective evaluation grading system. The evaluators were counseled to focus on the lower lip without regard to the upper lip.

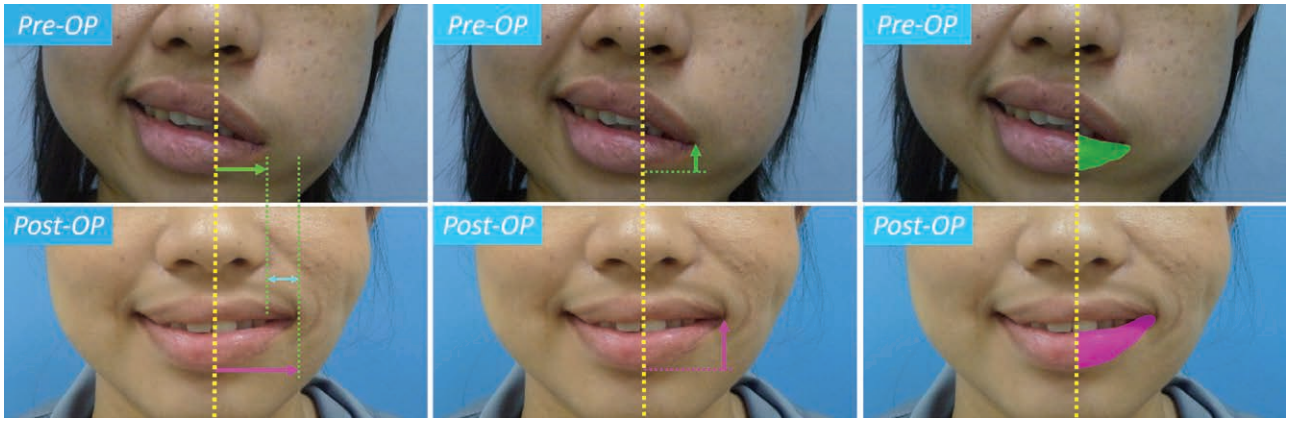

Fig. 8. Objective evaluation. Modified SMILE evaluation (Bray, 2010). Horizontal component (*left*). Vertical component (*center*). Area distribution (*right*).

transfer to the cervicofacial branch, direct neurotization of the depressor muscle, and facial-to-facial nerve transfer.[10] In response, Manktelow criticized such overly complicated procedures.[7] He recommended simpler procedures, either local injection of long-acting anesthetic drug (for a short requirement), or botulinum toxin (for a longer requirement) into the depressor labii

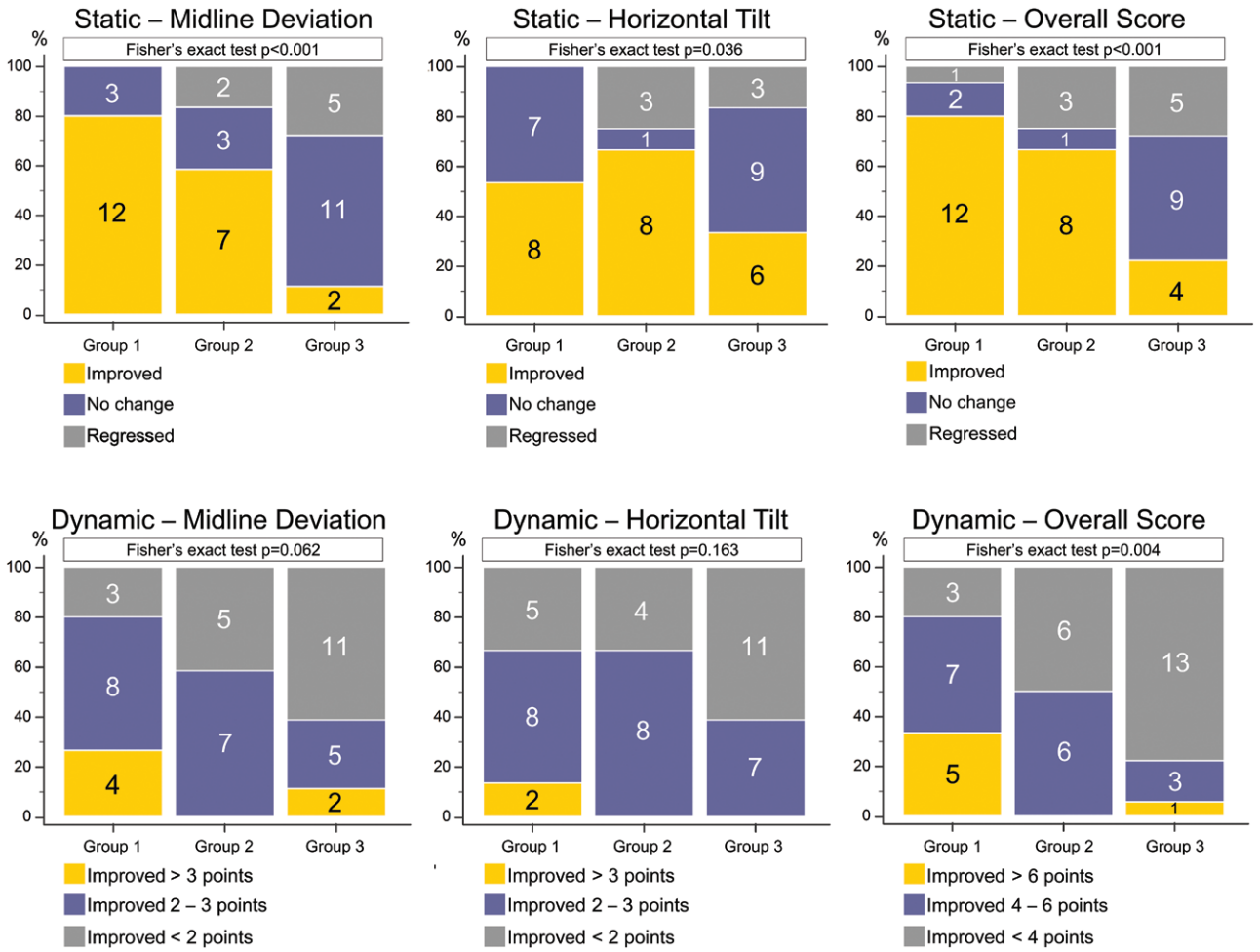

Fig. 9. (*Above*) Results of subjective evaluation; static status. (*Below*) Dynamic status. (*Left*) Midline deviation. (*Center*) Horizontal tilt. (*Right*) Overall score. The results of subjective evaluation are expressed as percentages of that group. (*Above*) In the static subjective evaluation, the distributions are classified as improved, no change, or regressed. (*Below*) In the dynamic subjective evaluation, there was an obvious improvement in all cases after functioning free muscle transplantation; therefore, the distributions are classified with regard to the degree of improvement.

inferioris muscle on the normal side, or a selective myectomy of the normal lower lip, all of which are easier procedures that can be accomplished safely and effectively.

From the senior author's experience on facial paralysis patients who underwent functioning free muscle transplantation for smile reanimation, synchronous movement of the lower lip with the upper lip can dramatically improve symmetry. Simply denervating the depressor muscles on the healthy side is insufficient for dynamic movement. Reinnervating the paralyzed depressor muscles (such as hypoglossal nerve or masseter nerve transfer to the cervicofacial trunk or mandibular branch) may create a "snarling" appearance that is inconsistent with a natural attractive smile.[23] Fixating the functioning free muscle transplantation to the mouth angle has a risk of creating a disfiguring dimpling to the mouth angle during smile. Attempts to replace the lower lip depressors with local muscle transfer are not recommended, as they may increase the risk for asymmetry at rest because of contracture.[24] This is why we performed simultaneous reconstruction of the lower lip by means of either a plantaris tendon graft or the gracilis aponeurosis for lateral, but not downward, pulling of the lower lip to help achieve dynamic smile symmetry.

Our method for smile reanimation involves harvesting a segment of the proximal gracilis muscle, usually from the contralateral thigh. The proximal portion of the muscle with its aponeurosis is reversed and fixed into the upper lip, and the distal end of the muscle is fixed to the periosteum of the inferior margin of the zygomatic arch.[1,3] If the patient has a complete palsy of the

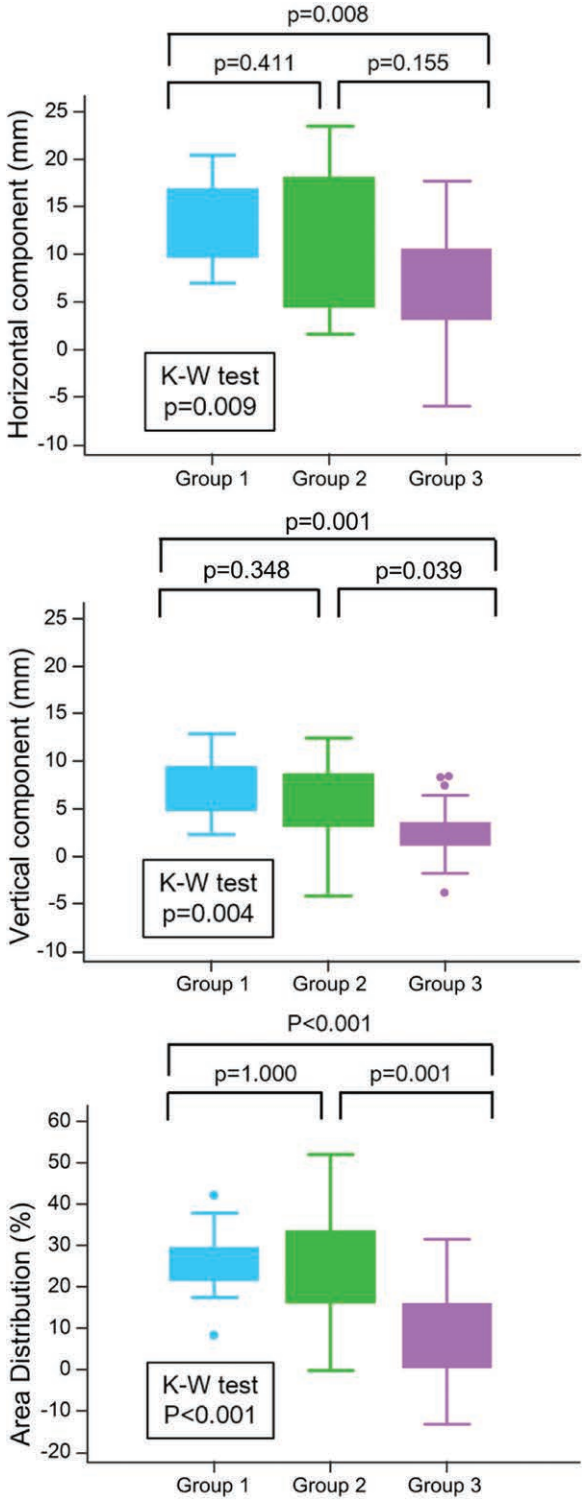

Fig. 10. Statistical results of objective evaluation. The *p* value between the groups (Dunn test) and the overall *p* value of the Kruskal-Wallis (*K-W*) test are all shown above the graphs.

upper and lower lip, simultaneous reconstruction of the lower lip will be performed while performing the standard gracilis inset for the upper lip

Table 2. Results of Objective Evaluation

	Group 1	Group 2	Group 3	*p*
Horizontal component (mm)	13.13	11.64	6.38	$p_{1\&2} = 0.009$† $p_{1\&2} = 0.411$ $p_{2\&3} = 0.155$ $p_{1\&3} = 0.008$†
Vertical component, mm	7.03	5.41	2.63	$p_{1\&2} = 0.004$† $p_{1\&2} = 0.348$ $p_{2\&3} = 0.039$† $p_{1\&3} = 0.001$†
Area distribution, %	26.78	25.53	7.57	$p_{1\&2} < 0.001$† $p_{1\&2} = 1.000$ $p_{2\&3} = 0.001$† $p_{1\&3} < 0.001$†

*Improvement of the paralyzed side of the lower lip after functioning free muscle transplantation. The results are expressed as mean in this table. The *p* values are the results of Kruskal-Wallis tests.
†The results are expressed as means.

elevation. Given the sufficient length of the plantaris tendon, the graft can be passed beyond the midline of the lower lip, giving more strength to pull the entire lower lip. The gracilis with its aponeurosis tail can only reach the ipsilateral lower lip because of its short length. This may explain why the plantaris tendon group provided better symmetry at dynamic status compared with the gracilis aponeurosis group.

In retrospect, there were two patients in the plantaris tendon group that required subsequent revisions of the anchored tendons. They were performed earlier in the series when we inadvertently created contour abnormalities. Both patients complained of tightness of the mouth angle and had compensatory tongue movement constantly. Both underwent tenotomy finally. One patient had a dominant dimpling deformity over the lower lip caused by contracture. Release of the contracture by two small incisions, full undermining of the underlying contracture, and placement of a dermofat graft were given as the secondary procedures. Therefore, the tension adjustment should be neither too tight nor too loose. Too much tension in setting the plantaris graft may create a tight band in the commissure that can restrict mouth opening. In addition, if it is put too superficial, it will create a severe dimpling deformity over the lower lip. To avoid these complications, the tension should be adjusted by pulling the tendon to see whether it could mobilize the midline of the lower lip approximately 5 mm toward the ipsilateral paralyzed side after tendon repair. The tendon graft should be also placed deeply inside the muscle, and not too superficial. There were no apparent complications in the group 2 patients. We made our incisions on the vermillion border of the lip for disguise. Incision

scars over the lower (or upper) lip were not often complained of by the patients.

Most of the patients that did not receive lower lip intervention (group 3) were from our earlier series of functioning free muscle transplantation, the period when we focused only on the upper lip. Indication and selection of which method is used for lower lip reconstruction is made according to the strength difference or prominence of the contraction of the healthy side of the lower lip depressors. Patients with bilateral Möbius syndrome are not required to undergo simultaneous reconstruction of the lower lip.

Limitations

Although this study suggested that simultaneous lower lip reconstruction during functioning free muscle transplantation has an important role in restoring lower lip symmetry for facial reanimation, the conclusions could be statistically more powered if there were more patients in each group. The uneven distribution of the various donor nerves used in each group was another confounding factor, but the percentage of one-stage donor nerves used in each group showed no significant difference.

CONCLUSIONS

Simultaneous lower lip intervention during functioning free muscle transplantation for facial reanimation reestablishes lower lip movement and improves overall symmetry in facial reanimation. By applying subjective and objective evaluations, both the plantaris tendon graft and the gracilis aponeurosis present significant improvement of symmetry and movement to the lower lip. The plantaris tendon graft can achieve the most lower lip excursion with overall improved smile symmetry. Not suspending the lower lip may have an unsatisfactory impact on the final outcome.

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CODING PERSPECTIVE

Coding perspective provided by Dr. Raymond Janevicius is intended to provide coding guidance.

15842 Graft for facial nerve paralysis; free muscle flap by microsurgical technique
20924 Tendon graft, from a distance (e.g., palmaris, toe extensor, plantaris)

- The free gracilis muscle flap is reported with code 15842.
- The free muscle flap code, 15756, should not be reported, as code 15842 is more specific for facial paralysis.
- The free muscle flap code, 15842, does not include tendon grafting. The plantaris tendon graft is reported with code 20924.
- Since the tendon graft is an additional procedure, the multiple procedure modifier, 51, is appended:

15842 Free gracilis muscle transfer for facial paralysis
20924-51 Plantaris tendon graft.

CODING PRINCIPLE: Free flap codes are global and include:

- Harvest of the free flap
- Dissection of donor vessels
- Straightforward closure of donor site
- Dissection and isolation of recipient vessels
- Microvascular anastomosis of one artery and two veins
- Use of the operating microscope
- Inset of the flap
- Straightforward wound closure
- Monitoring of the flap intraoperatively and postoperatively

Additional procedures, such as tendon grafts, vein grafts, or skins grafts, are reported in addition to the free flap codes.

Disclosure: Dr. Janevicius (janeviciusray@comcast.net) is the president of JCC, a firm specializing in coding consulting services for surgeons, government agencies, attorneys, and other entities.

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