Cross-Face Nerve Grafting versus Masseteric-to-Facial Nerve Transposition for Reanimation of Incomplete Facial Paralysis: A Comparative Study Using the FACIAL CLIMA Evaluating System

Bernardo Hontanilla, M.D., Ph.D.
Jesús Olivas, M.D.
Álvaro Cabello, M.D., Ph.D.
Diego Marré, M.D.

Navarra, Spain

Background: Incomplete facial paralysis is still a challenge because we must restore what is missing without causing damage to what has recovered. The current literature is insufficient, with a small number of cases. The use of nerve transfers has gained recent popularity for reanimating facial palsy. The authors present a comparative study between cross-face nerve grafting and masseteric-to-facial nerve transposition for incomplete facial paralysis.

Methods: Twenty-eight patients with incomplete unilateral facial paralysis were reanimated with either cross-face nerve grafting (group I, $n = 10$) or masseteric nerve transfer (group II, $n = 18$). Commissural displacement and commissural contraction velocity were measured using the FACIAL CLIMA dystem. Spontaneity of the movement and satisfaction were also assessed.

Results: When comparing the reconstructed and the healthy sides, statistical differences were found in group I but not in group II, suggesting that the resulting movement was symmetrical in group II but not in group I. Intergroup comparison showed that both commissural displacement and commissural contraction velocity were higher in group II. Spontaneity in group I was higher than in group II, but patients in group II showed more satisfaction, both without being statistically significant.

Conclusions: Reanimation of incomplete facial paralysis can be satisfactorily achieved with both cross-face nerve grafting and direct masseteric-to-facial nerve transposition. However, with the masseteric nerve, better symmetry, a higher degree of recovery, and an increased level of satisfaction are achieved in a one-stage operation. Furthermore, both nerve sources are able to restore spontaneity in more than 50 percent of the patient's daily life, with no significant differences between them. (*Plast. Reconstr. Surg.* 142: 179e, 2018.)

CLINICAL QUESTION/LEVEL OF EVIDENCE: Therapeutic, III.

3
THERAPEUTIC

Incomplete facial paralysis results from facial nerve injury with remnant axons, insufficient spontaneous growing of axons, and even aberrant regeneration. The most common cause of this type of facial paralysis is Bell palsy, an acute, idiopathic, and usually unilateral facial paralysis that typically resolves spontaneously in approximately two-thirds of patients within the first 6 months after onset. The remaining third have an incomplete recovery characterized by a symmetrical tone at rest but with muscular weakness, motor synkinesis, and hemifacial spams at movement, leaving undesired cosmetic sequelae.

From the Department of Plastic and Reconstructive Surgery, Clinica Universidad de Navarra.
Received for publication July 21, 2017; accepted March 1, 2018.

DOI: 10.1097/PRS.0000000000004612

Disclosure: *All the authors declare that they have no financial interest in the methodology described. There was no source of funds supporting this work.*

Supplemental digital content is available for this article. Direct URL citations appear in the text; simply type the URL address into any Web browser to access this content. Clickable links to the material are provided in the HTML text of this article on the *Journal*'s website (www.PRSJournal.com).

Despite the efforts of different authors to satisfactorily treat incomplete longstanding facial paralysis, this operation remains a challenge. Options of reanimation in these cases include hypoglossal-to-facial nerve transfer with nerve grafts, one-stage muscle transfer, and temporalis transposition.[1–5] Cross-face nerve grafting has also been described for this type of facial palsy,[6,7] but it also has some major downsides, including not being able to produce sufficient excursion on the affected side, which is probably caused by the limited donor axonal load and the presence of two sites of coaptation. In addition, and more critically, the cross-face nerve grafting does not guarantee recovering the spontaneous smile in all cases.

In 2015, our group described the masseteric-to-facial nerve transposition as a reliable alternative technique for reanimation of the incomplete facial paralysis with satisfactory results.[8] Apart from providing a strong smile, the masseteric nerve is also able to reestablish a spontaneous smile.[9] Notwithstanding, some authors are not prone to accept that the masseteric nerve could restore the patient's ability to smile spontaneously, maintaining that cross-face nerve grafting is the only procedure that can provide a spontaneous smile.[10–12] The purpose of the present study was to compare commissural displacement, contraction velocity, satisfaction, and spontaneity after reanimation of the incomplete facial paralysis using cross-face nerve grafting or masseteric-to-facial transposition.

PATIENTS AND METHODS

Between December of 2013 and October of 2016, 28 patients with incomplete unilateral facial paralysis were reanimated with either cross-face nerve grafting ($n = 10$) or masseteric nerve transfer ($n = 18$) in our institution. All operations were performed by the senior author (B.H.) after a minimum of 12 months with no electrophysiologic recovery or clinical improvement in acute cases. For all patients, sex, age at surgery, cause of disease, time of evolution, and complications were registered. In all cases, a complete evaluation including physical examination, standard photographs and video, satisfaction questionnaire, and spontaneous smile achievement was conducted preoperatively and postoperatively. Commissural displacement and commissural contraction velocity were measured using the FACIAL CLIMA system, which provides dynamic three-dimensional information that allows comparison of results obtained after reanimation with different techniques.[13–16]

Spontaneous smile recovery was determined by means of a questionnaire inspecting for spontaneity and by assessing the patient's video while smiling at home. The questionnaire was previously sent to the closest relative of the patient and requested information regarding the presence of spontaneity and the percentage of time in which it was present during the patient's daily life. This test was a single-answer, four-question test asking about spontaneous smile recovery after 48 hours. The possible answers were as follows:

1. Spontaneous smile has never been achieved.
2. Spontaneous smile is observed in less than 50 percent of the patient's daily life.
3. Spontaneous smile is observed in more than 50 percent of the patient's daily life.
4. Spontaneous smile is observed always.

The questionnaire was completed by the closest relative of the patient, as we think that person could evaluate the entire follow-up of the patient and avoid bias generated by a self-questionnaire. The video was a humorous video that was previously sent by our team to the patient's relative to avoid bias, secondary to advising the patient that he or she was going to receive a hilarious stimulus.[17]

For qualitative evaluation, patients were assessed in our clinic 1 year after the operation by the following two questions: Are you satisfied with the result? Would you undergo surgery again? Only when patients answered positively to both questions was the result considered satisfactory.

Operative Technique

Cross-Face Nerve Grafting

First Stage.

Through a preauricular incision on the healthy side, the zygomaticofacial trunk was identified. Using a nerve stimulator (Aesculap, Tottlingen, Germany), two nerve branches producing pure activation of the zygomaticus major muscle were selected and transected. At the same time, the sural nerve was harvested by means of two or three horizontal incisions and connected reversely using 10-0 nylon sutures. The distal stump of the nerve graft was marked with a 5-0 nylon stitch and then tunneled across the midline and buried in the subcutaneous tissue of the preauricular region of the paralyzed side.

Second Stage.

Once the Tinel sign was noted when the paretic side was tapped (mean, 218 days in our series), the second stage was performed. Through a similar approach on the paretic side, the facial nerve branches were identified at the anterior border of the parotid gland. Next, two zygomatic branches were identified using the nerve stimulator and divided, connecting their distal stump to the nerve graft using 10-0 nylon epineural sutures.

Masseteric Nerve Transposition

A cheek flap is raised by a supra–superficial musculoaponeurotic system dissection through a preauricular incision on the paralyzed side until the anterior margin of the parotid gland and the zygomaticofacial trunk and its divisions can be seen (Fig. 1). A branch that produces a noticeable commissural excursion is selected. Then, the masseteric nerve is harvested as described previously.[18] The nerve is then dissected distally and, once adequate length has been obtained, it is transected and transposed superficially, being coapted to the previously selected branches of the facial nerve in end-to-end fashion with a 10-0 nylon epineural suture.

Rehabilitation Protocol

All patients were instructed to carry out a biofeedback rehabilitation protocol consisting of smiling in front of a mirror for 10 minutes daily, with training starting 1 month after surgery (1 month after the second stage in cross-face nerve grafting) and continuing until 6 months after surgery. No formal physical therapy or other methods were indicated.

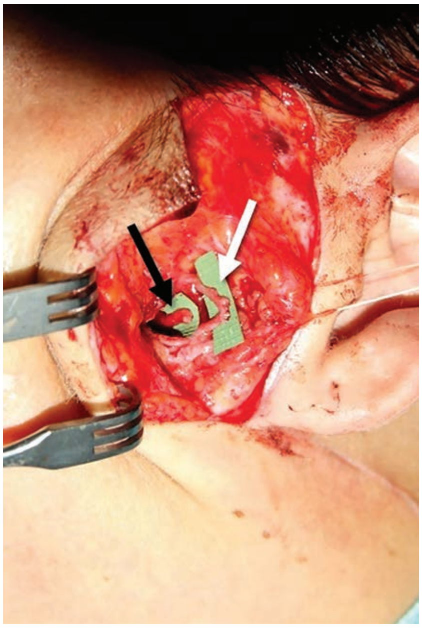


Fig. 1. Intraoperative view of the masseteric nerve (*black arrow*) and a zygomatic branch of the facial nerve (*white arrow*) before coaptation.

Statistical Analysis

To compare the effectiveness of the techniques performed, the following parameters were evaluated in each patient by means of the FACIAL CLIMA system. Commissural contraction velocity and oral commissure displacement were obtained from the normal and reanimated sides. Patients were analyzed 1 year after surgery. First, to evaluate the degree of symmetry obtained with each technique, intragroup comparison of commissural displacement and commissural contraction velocity of the reanimated versus the normal side of each patient was conducted. Then, the most symmetrical smile would be considered when differences between both sides were not addressed. In contrast, when obtaining significant differences between the two sides, it would mean that both sides presented different features and therefore the movement was not symmetrical. Next, to assess the degree of recovery, after reanimation, the values of commissural displacement and commissural contraction velocity were transformed into a percentage of recovery, with the normal side representing 100 percent. Because all patients presented with incomplete paralysis, both commissural contraction velocity and commissural displacement were different in the preoperative situation between the individuals in our sample. For this reason, each subject was compared with himself or herself, avoiding biased comparisons between different individuals. Posteriorly, a mean percentage of recovery of commissural displacement and commissural contraction velocity was obtained for each technique, considering each patient's healthy side as the reference (i.e., 100 percent). Finally an intragroup analysis of the preoperative and postoperative commissure displacement was carried out to calculate the change after surgery. Also, the intergroup comparison of that change was analyzed.

For intragroup analysis of commissural displacement and commissural contraction velocity, the Wilcoxon signed rank test was used. For intergroup comparisons, all demographic and quantitative variables were compared using the Mann-Whitney *U* test. Sex, satisfaction, and spontaneity ratios were compared using the Fisher's exact test. IBM SPSS Version 23.0 (IBM Corp., Armonk, N.Y.) was used to analyze results and perform all statistical tests, with significance set at $p < 0.05$.

RESULTS

Groups were comparable regarding sex, age, time of evolution, and follow-up (Table 1). The main cause of incomplete facial paralysis was Bell palsy, although other types were observed (Table 2).

In group I (cross-facial nerve grafting), the median oral commissure displacement 2 years after surgery was 8.7 mm (range, 7.1 to 11.9 mm) on the healthy side and 5.9 mm (range, 3.1 to 11.8 mm) on the reanimated side ($p = 0.001$). Median postoperative commissural contraction velocity was 33.6 mm/second (range, 25.3 to 42.0 mm/second) on the healthy side and 23.5 mm/second (range, 17.8 to 14.1 mm/second) on the reanimated side ($p = 0.019$) (Table 3 and Fig. 2). (**See Video, Supplemental Digital Content 1**, which shows the preoperative appearance of a 48-year-old woman with incomplete right facial paralysis secondary to cholesteatoma, ***http://links.lww.com/PRS/C879***. **See Video, Supplemental Digital Content 2**, which shows the same patient from Video 1 after facial reanimation by cross-facial nerve graft at 24 months after surgery, ***http://links.lww.com/PRS/C880***.)

Table 1. Patient Demographics

	Surgical Technique		
Variable	CFNG	Masseteric-to-Facial Nerve Transposition	p*
No.	10	18	
Sex			
Male	3	5	1.00
Female	7	13	
Age, yr			
Median	37	31	
Range	19–58	16–43	0.41
Evolution, mo			
Median	36	40.5	
Range	26–54	23–60	0.46
Follow-up, mo			
Median	31	29	
Range	24–47	25–44	0.21

CFNG, cross-facial nerve graft.
*Fisher's exact test shows no significant differences in sex distribution between the groups. Similarly, the Mann-Whitney *U* test shows no significant differences for the rest of the variables.

Table 2. Cause of Paralysis

	Surgical Technique	
	CFNG	Masseteric-to-Facial Nerve Transposition
Bell palsy	6	9
Ramsay Hunt syndrome	1	4
Cholesteatoma	2	2
Congenital	1	0
Acoustic neurinoma	0	3
Total	10	18

CFNG, cross-facial nerve graft.

In group II (masseteric), the median oral commissure displacement 2 years after surgery was 9.3 mm (range, 6.8 to 12.0 mm) on the healthy side and 7.6 mm (range, 4.7 to 13.3 mm) on the reanimated side ($p = 0.52$). The median postoperative commissural contraction velocity was 36.2 mm/second (range, 25.7 to 42.1 mm/second) on the healthy side and 33.1 mm/second (range, 19.3 to 38.8 mm/second) on the reanimated side ($p = 0.35$) (Table 3 and Figs. 3 and 4). (**See Video, Supplemental Digital Content 3**, which shows the preoperative appearance of the patient in Fig. 3, ***http://links.lww.com/PRS/C881***. **See Video, Supplemental Digital Content 4**, which shows the postoperative appearance of the patient in Fig. 3 at 18 months after masseteric-to-facial nerve transposition, ***http://links.lww.com/PRS/C882***. **See Video, Supplemental Digital Content 5**, which shows the preoperative appearance of the patient in Fig. 4, ***http://links.lww.com/PRS/C883***. **See Video, Supplemental Digital Content 6**, which shows the postoperative appearance of the patient in Fig. 4 at 12 months after masseteric-to-facial nerve transposition, ***http://links.lww.com/PRS/C884***.)

For intergroup comparisons, the commissural displacement of the reanimated side showed significant differences, with higher excursion in group II (5.9 versus 7.6; $p = 0.046$). Commissural contraction velocity was also higher in group II but not statistically significantly so (23.5 versus

Table 3. Intragroup Comparison of Commissure Displacement and Commissure Contraction Velocity between the Healthy and the Reanimated Sides

	Commissure Displacement (mm)			Commissure Contraction Velocity (mm/second)		
Group	Healthy	Reanimated	p*	Healthy	Reanimated	p*
I (CFNG)			0.001			0.019
Median	8.7	5.9		33.6	23.5	
Range	7.1–11.9	3.1–11.8		25.3–42.0	17.8–31.9	
II (masseteric-to-facial nerve transposition)			0.52			0.35
Median	9.3	7.6		36.2	33.1	
Range	6.8–12.0	4.7–13.3		25.7–42.1	19.3–38.8	

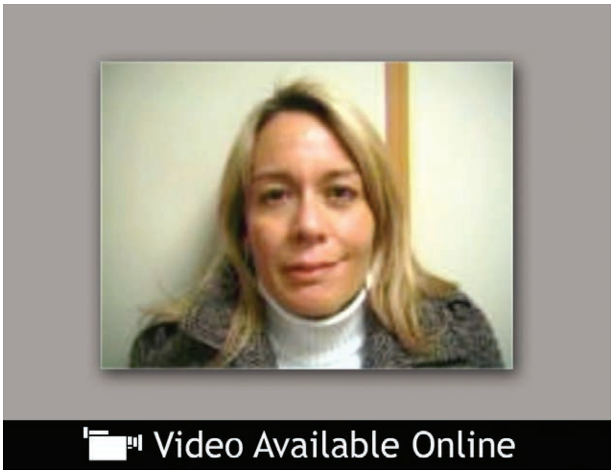
CFNG, cross-facial nerve graft.
*The Wilcoxon signed rank test was used, showing statistical differences between healthy and reanimated sides in group I but not in group II.

Fig. 2. A 45-year-old woman with left incomplete facial paralysis secondary to Bell palsy 3 years previously. (*Above*, *left*) Preoperatively at rest and (*above*, *right*) when smiling. A cross-facial nerve graft was performed for smile reanimation. (*Below*, *left*) The patient 1 year postoperatively at rest and (*below*, *right*) when smiling.

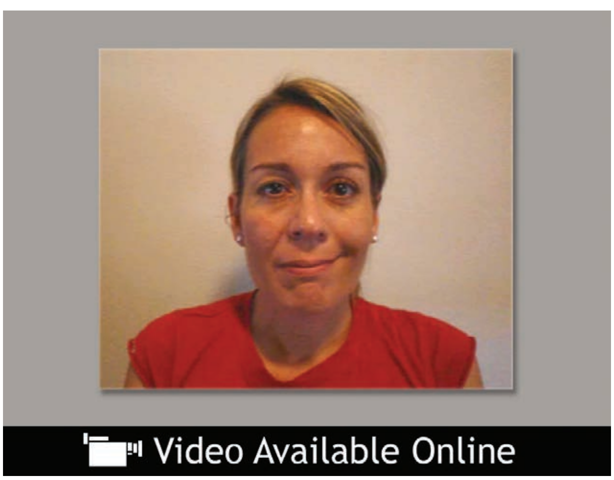
33.1; $p = 0.22$). Similarly, percentage of recovery of both parameters was higher in group II, with a significant difference for commissural displacement (63.2 versus 90.5; $p = 0.039$) but not for commissural contraction velocity (81.4 versus 94.1; $p = 0.43$) (Table 4).

When comparing the preoperative and postoperative commissural displacement, significant differences were observed in group I ($p = 0.005$) and in group II ($p = 0.005$), with a median change of 1.3 mm (range, 0.1 to 4.5 mm) in group I and 3.2 mm (range, 0.2 to 7.3 mm) in group II (Table 5). However, the comparison of this change between group I and group II did not show significant differences (Table 6).

Finally, spontaneous smile recovery during more than 50 percent of the patient´s daily life was 80 percent in group I and 55.5 percent in group II. In contrast, satisfaction was superior in group II. No statistical significance was found



Video 1. Supplemental Digital Content 1, which demonstrates the preoperative appearance of a 48-year-old woman with incomplete right facial paralysis secondary to cholesteatoma, ***http://links.lww.com/PRS/C879***.



Video 2. Supplemental Digital Content 2, which shows the same patient from Video 1 after facial reanimation by cross-facial nerve graft at 24 months after surgery, ***http://links.lww.com/PRS/C880***.

(Table 7). (**See Video, Supplemental Digital Content 7**, which shows the postoperative appearance of the patient in Fig. 3 when smiling while hearing a joke after masseteric-to-facial nerve transposition, ***http://links.lww.com/PRS/C885***.)

DISCUSSION

Selection of the correct technique to reanimate a partially paralyzed face is still a challenge because we must restore what is missing without causing damage to what has recovered. When reviewing the current literature, it is surprising to note that dynamic reanimation of incomplete facial paralysis has not been as thoroughly addressed as its complete counterpart. The smaller number of cases, the coping of patients, and the more extended use of nonsurgical therapies are probably some of the reasons that explain this. Surgical options for reanimation of incomplete facial paralysis include transposition of the hypoglossal nerve, free muscle transfer, temporalis-lengthening myoplasty, cross-face nerve grafting, and masseteric nerve transfer.[1–8]

In 2007, Yamamoto et al. introduced the neural supercharge concept through a facial–hypoglossal network system, hypothesizing that the remaining potential of the incompletely paralyzed muscles is activated by a neural supercharge effect.[2] However, this technique may produce synkinesis or mass movements when the coaptation is made to the facial nerve trunk even with end-to-side neurorrhaphy. In addition, an interpositional nerve graft to connect both nerves is needed. Other authors have reported the use of one-stage free muscle transfer with latissimus dorsi minigraft, with significant improvement of symmetry on smile. In this sense, Takushima et al. argue that such an approach offers an assured method with which adequate muscle contraction can be obtained, suggesting that it may be superior to cross-facial nerve grafting with or without muscle transfer, although they made no formal comparison and no videos are available.[3] However, to recommend a free tissue transfer without offering the patient a chance of rehabilitation with "simpler" techniques may seem somewhat aggressive.

Another technique reported for reanimation of incomplete facial palsy is temporalis lengthening myoplasty, described by Aum et al.[4] This technique, although sharing some common ground with the masseteric nerve transfer, has some drawbacks. In the first place, it is more traumatic, as it requires osteotomy of the coronoid process and incisions in the nasolabial fold. Second, harvesting strips of fascia lata adds to the morbidity. Third, in the tunneling of the fascial strips, there could be inadvertent injury to the remaining facial innervation. Fourth, should the masseteric nerve transposition not work, the temporalis can always be a valuable second choice, but by doing it the other way around, scarring and manipulation from a temporalis-lengthening myoplasty might render the masseteric nerve harder to locate and transpose. Chen et al. have introduced a modification that avoids the nasolabial intermittent incisions and uses a palmaris longus tendon instead of fascia lata, but the other drawbacks are still present.[5] Nevertheless, new modifications of the temporalis lengthening myoplasty when treating complete

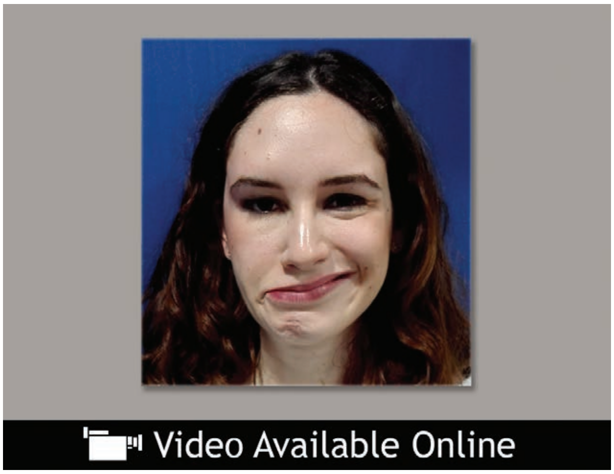
Fig. 3. A 32-year-old woman with right incomplete facial paralysis secondary to Bell palsy with aberrant regeneration. (*Above*, *left*) Preoperatively at rest and (*above*, *right*) when smiling. A masseteric-to-facial nerve transposition was performed for smile reanimation. (*Below*, *left*) The patient 18 months postoperatively at rest and (*below*, *right*) when smiling.

facial paralysis may also be addressed specifically for incomplete paralysis.

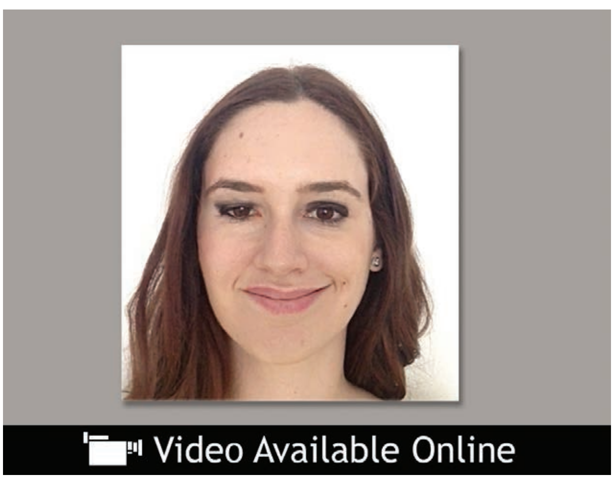
Like other authors, we first used cross-facial nerve grafting for reanimation of incomplete facial paralysis.[6] Among the main advantages of this technique is the ability to restore a smile that is apparently spontaneous and coordinated with the contralateral side, although in our sample, no spontaneity was observed in two cases. Nevertheless, the technique has some disadvantages. First, two stages are required, although some authors have advocated a one-stage procedure. In this sense, Frey et al. recommend one-stage cross-face nerve grafting with end-to-side coaptation distally on the recipient nerve of the paralyzed side.[7] The authors reported three cases, with one of the patients showing a high degree of asymmetry, and another one having a short

Fig. 4. A 27-year-old woman with left incomplete facial paralysis secondary to resection of an acoustic neurinoma. (*Above*, *left*) Preoperatively at rest and (*above*, *right*) when smiling. A masseteric-to-facial nerve transposition was performed for smile reanimation. (*Below*, *left*) The patient 12 months postoperatively at rest and (*below*, *right*) when smiling.

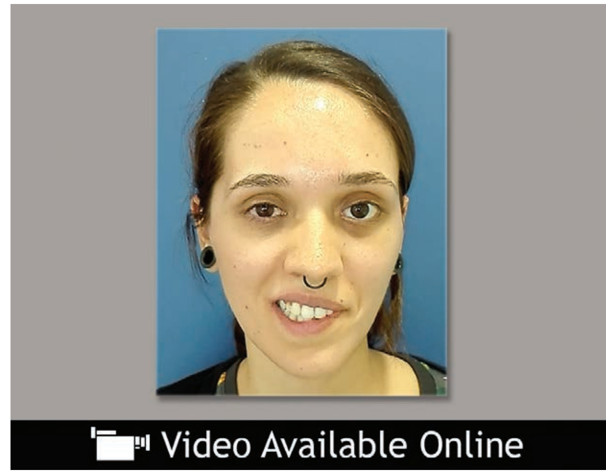
follow-up of 10 months. Moreover, no videos were reported in the article. For these reasons, the real advantages over traditional end-to-end coaptation remain to be investigated. Despite the mentioned variation, we still prefer a two-stage approach to ensure that the axonal load grows exclusively from the healthy side to the affected side, avoiding the growing of axons from the affected side into the nerve graft; because these are incomplete paralysis cases, this remains a possibility. Another disadvantage of cross-facial nerve grafting is that it needs a donor nerve, which carries some morbidity. Furthermore, when a nerve graft is used, the axons must cross two sites of coaptation, which may result in suboptimal reinnervation of the target muscle. Our analysis showed statistical differences for commissural displacement and commissural contraction velocity in the cross-facial



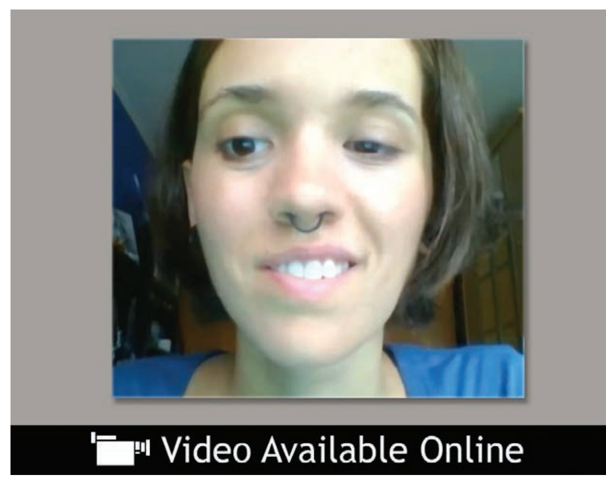
Video 3. Supplemental Digital Content 3, which shows the preoperative appearance of the patient in Figure 3, ***http://links.lww.com/PRS/C881***.



Video 4. Supplemental Digital Content 4, which shows the postoperative appearance of the patient in Figure 3 at 18 months after masseteric-to-facial nerve transposition, ***http://links.lww.com/PRS/C882***.



Video 5. Supplemental Digital Content 5, which shows the preoperative appearance of the patient in Figure 4, ***http://links.lww.com/PRS/C883***.



Video 6. Supplemental Digital Content 6, which shows the postoperative appearance of the patient in Figure 4 at 12 months after masseteric-to-facial nerve transposition, ***http://links.lww.com/PRS/C884***.

nerve grafting group, suggesting an asymmetrical movement (in quantitative terms) compared with the healthy side.

Masseteric-to-facial nerve transposition has gained increasing popularity for reanimation of complete and incomplete facial paralysis.[8,15–22] This nerve offers several advantages for partial reanimation. First, it is a one-stage procedure, which is a major advantage over the two-stage cross-facial nerve graft. Second, one of the main advantages attributed to this nerve is its strength of pull, which allows, on the one hand, reanimation of strong smiles and, on the other hand, acquisition of very good symmetry at rest and when smiling. This particularity is very likely explained by the high axonal load that can be delivered with this nerve in comparison with others, such as cross-facial nerve grafting. Furthermore, because it is in close proximity to the branching of the facial nerve within the parotid gland, it is possible to select one specific trunk or branch directed to the middle-lower third of the face, and so preserve all recovered branches of the facial nerve, which is paramount when treating incomplete palsy. Lastly, the proximity between the masseteric nerve and branches of the facial nerve eliminates the need to use a nerve graft, and thus reduces the morbidity of the whole procedure and avoids the loss of power that is attributed to the use of grafts when there are two coaptation sites. It is important to note that given the loss of a functioning zygomatic or buccal branch, a transient worsening of both

Table 4. Intergroup Comparison of Commissure Displacement and Commissure Contraction Velocity between the Healthy and Reanimated Sides, and Percentage of Recovery

	Healthy Side		Reanimated Side		Recovery (%)	
Group	CD (mm)	CCV (mm/sec)	CD (mm)	CCV (mm/sec)	CD	CCV
I (CFNG)						
Median	8.7	33.6	5.9	23.5	63.2	81.4
Range	7.1–11.9	25.3–42.0	3.1–11.8	17.8–31.9	39.4–72.1	53.0–89.3
II (masseteric-to-facial nerve transposition)						
Median	9.3	36.2	7.6	33.1	90.5	94.1
Range	6.8–12.0	25.7–42.1	4.7–13.3	19.3–38.8	65–96.2	65.9–95.6
p*	0.61	0.46	0.046	0.22	0.039	0.43

CD, commissural displacement; CCV, commissure contraction velocity; CFNG, cross-facial nerve graft.
*The Mann-Whitney *U* test shows statistical differences in commissural displacement of the reanimated side and in commissural displacement recovery; both values are higher in group II.

Table 5. Intragroup Comparison of Preoperative and Postoperative Commissure Displacement

	Cross-Facial Nerve Grafting			Masseteric-to-Facial Nerve Transposition		
Case	Preoperative (mm)	Postoperative (mm)	Change (mm)	Preoperative (mm)	Postoperative (mm)	Change (mm)
1	6.1	10.6	4.5	7.6	11.5	3.9
2	4.6	6.1	1.5	4.8	7.1	2.3
3	4.7	5.6	0.9	2.1	5.8	3.7
4	2.9	3.2	0.3	5.2	11.2	6.0
5	7.6	9.8	2.2	1.7	4.4	2.7
6	1.8	1.9	0.1	4.9	5.1	0.2
7	2.1	3.2	1.1	2.1	3.8	1.7
8	6.4	9.1	2.7	6.2	10.1	3.9
9	3.1	4.2	1.1	1.6	2.9	1.3
10	6.4	8.7	2.3	5.4	9.7	4.3
11				6.3	10.9	4.6
12				2.5	5.1	2.6
13				2.3	7.9	5.6
14				3.9	11.2	7.3
15				7.2	9.4	2.2
16				5.2	7.2	2.0
17				4.3	6.9	2.6
18				6.8	11.3	4.5
Median	4.7	5.9	1.3	4.9	7.6	3.2
Range	1.8–7.6	1.9–10.6	0.1–4.5	1.6–7.6	2.9–11.5	0.2–7.3
p*	0.005			0.000		

*The Wilcoxon signed rank test was used, showing statistical differences between preoperative and postoperative results for each technique.

Table 6. Intergroup Comparison of Commissural Displacement Change

	Change CFNG	Change Masseteric-to-Facial Nerve Transposition
Median	1.3	3.2
Range	0.1–4.5	0.2–7.3
p*	0.13	

CFNG, cross-facial nerve graft.
*The Mann-Whitney *U* test shows no statistical differences between the techniques' change.

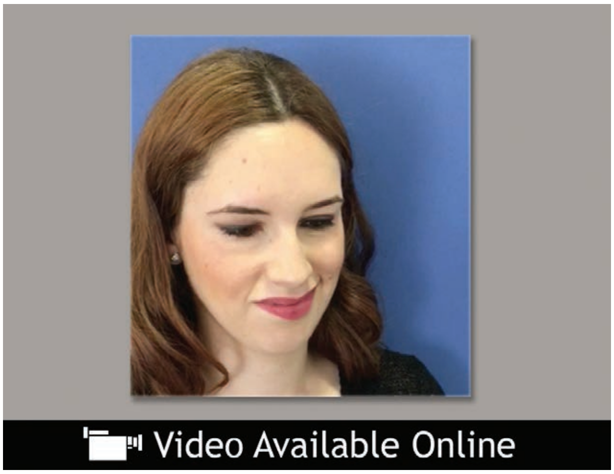
Table 7. Intergroup Comparison of Satisfaction and Spontaneity*

Group	SP-to-NSP Ratio (% SP)	SS-to-NSS Ratio (% SS)
I (CFNG)	8:2 (80.0)	8:2 (80.0)
II (masseteric-to-facial nerve transposition)	16:2 (88.8)	10:8 (55.5)
p	0.60	0.25

SP, satisfied patients; NSP, nonsatisfied patients; SS, spontaneous smile; NSS, nonspontaneous smile; CFNG, cross-facial nerve graft.
*Fisher's exact test shows no significant differences in satisfaction and spontaneity between the groups.

the static and dynamic paresis is expected during the early postoperative period. Patients must be warned about this and reassured that it will improve once the masseteric nerve reinnervates that branch. The previous explanation of the transient worsening caused 15 patients to reject the masseteric-to-facial transposition for reanimation of their incomplete facial paralysis.

In the present work, we have observed significantly better outcomes of symmetry, commissure excursion, and velocity in the group of patients



Video 7. Supplemental Digital Content 7, which shows the postoperative appearance of the patient in Figure 3 when smiling while hearing a joke after masseteric-to-facial nerve transposition, ***http://links.lww.com/PRS/C885***.

with the masseteric nerve transposition. In an initial analysis, statistical differences for commissural displacement and commissural contraction velocity were observed in group I (cross-facial nerve grafting) but not in group II (masseteric-to-facial nerve transposition), suggesting that with the masseteric nerve, a movement more similar to the normal side is obtained. In the second analysis, we compared the postoperative means of commissural displacement and commissural contraction velocity between the groups. Both parameters were higher in group II, with statistical significance for commissural displacement. Finally, patients with a cross-facial nerve graft recovered a median of 63.2 percent of commissural displacement compared with the contralateral side, whereas patients with masseteric neurotization showed a median recovery of 90.5 percent ($p = 0039$). Commissural contraction velocity recovery was also higher in group II, although statistical significance was not reached.

The main disadvantage of using the motor nerve to the masseter for facial reanimation is the issue of movement dissociation and spontaneity. As far as movement dissociation is concerned, during the first months after onset of movement, patients are instructed to chew to activate the facial musculature. Later, when reinnervation is nearly complete, they are told to practice smiling by "triggering"; that is, to activate the movement of smile by only slightly clenching the teeth without completely biting. Eventually, a number of patients achieve this to varying extents.[23–27] Spontaneity, however, seems harder to restore, as it has to do with the ability to smile involuntarily in response to a humorous stimulus which, theoretically, can only be obtained if the movement is triggered by the facial nerve itself. Nevertheless, several authors have reported on patients achieving a spontaneous smile after reanimation with the masseteric nerve. In this sense, our group has demonstrated that women recover spontaneous smile at a higher rate and earlier than men after using masseteric nerve in complete facial palsy reanimation,[9] supported by the different connectivity patterns between men and women,[28] and with prediction of which patients will achieve it not being possible. In the present study, we have observed a higher rate of spontaneity when comparing spontaneous smile recovery during more than 50 percent of the patient's daily life. This rate was 80 percent in group I (cross-facial nerve

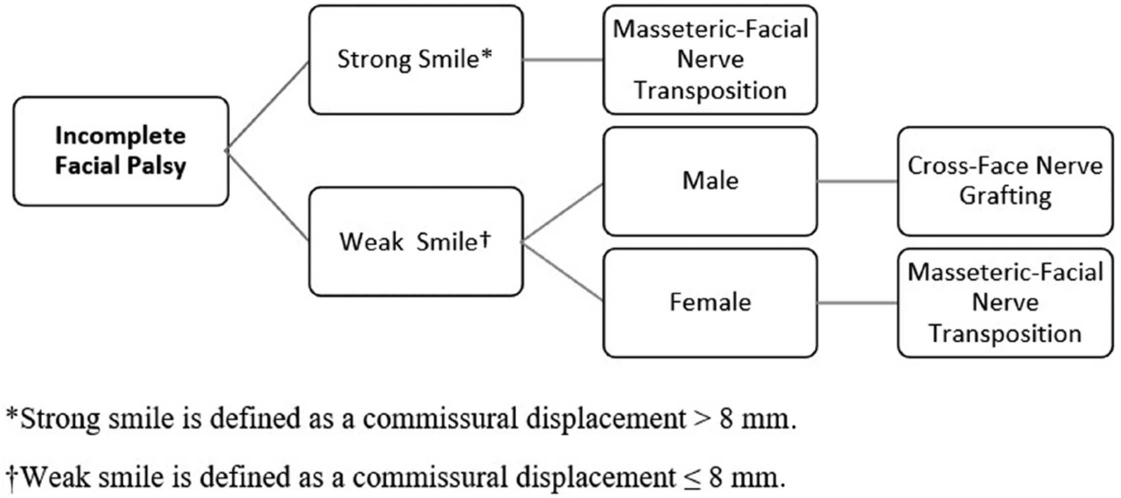


Fig. 5. Schematic algorithm for treating incomplete facial paralysis depending on the patient's gender and smile type.

grafting) and 55.5 percent in group II (masseteric-to-facial nerve transposition), with no significant differences between the groups. However, satisfaction was higher in group II, probably because masseteric-to-facial nerve transposition is not only a simpler one-stage technique but also allows them to achieve better symmetry when smiling. Sex differences were not assessed because of the small number of patients in each group.

Regarding the number of patients included in our study, we are aware that a larger sample size would serve to confirm our results. However, judging by our clinical observations and the statistical analyses conducted, we have observed promising results not only in nerve regeneration but also in functional recovery. For these reasons, masseteric-to-facial nerve transposition could become a technique of choice for smile rehabilitation of patients with incomplete facial paralysis in our institution, especially in women (Fig. 5).

CONCLUSIONS

These results indicate that reanimation of incomplete facial paralysis can be satisfactorily achieved with both cross-facial nerve grafting and direct masseteric-to-facial nerve transposition. Moreover, its constant anatomy, considerable load of axons, strong pull, only one stage, fast recovery, and higher satisfaction compared with cross-facial nerve grafting results, and absence of nerve grafting morbidity, could make the masseteric nerve transposition the first choice for incomplete facial paralysis restoration. In addition, the masseteric nerve can restore spontaneity, but we are unable to predict which patients will achieve it.

Bernardo Hontanilla, M.D., Ph.D.
Department of Plastic and Reconstructive Surgery
Clinica Universidad de Navarra
Av. Pio XII 36
31008 Pamplona, Spain
bhontanill@unav.es

PATIENT CONSENT

Patients provided written consent for the use of their images.

REFERENCES

1. Terzis JK, Karypidis D. Therapeutic strategies in post-facial paralysis synkinesis in adult patients. *Plast Reconstr Surg.* 2012;129:925e–939e.
2. Yamamoto Y, Sekido M, Furukawa H, Oyama A, Tsutsumida A, Sasaki S. Surgical rehabilitation of reversible facial palsy: Facial–hypoglossal network system based on neural signal augmentation/neural supercharge concept. *J Plast Reconstr Aesthet Surg.* 2007;60:223–231.
3. Takushima A, Harii K, Okazaki M, Ohura N, Asato H. Availability of latissimus dorsi minigraft in smile reconstruction for incomplete facial paralysis: Quantitative assessment based on the optical flow method. *Plast Reconstr Surg.* 2009;123:1198–1208.
4. Aum JH, Kang DH, Oh SA, Gu JH. Orthodromic transfer of the temporalis muscle in incomplete facial nerve palsy. *Arch Plast Surg.* 2013;40:348–352.
5. Chen G, Yang X, Wang W, Li Q. Mini-temporalis transposition: A less invasive procedure of smile restoration for long-standing incomplete facial paralysis. *J Craniofac Surg.* 2015;26:518–521.
6. Hontanilla B, Marre D, Cabello A. Cross-face nerve grafting for reanimation of incomplete facial paralysis: Quantitative outcomes using the FACIAL CLIMA system and patient satisfaction. *J Reconstr Microsurg.* 2014;30:25–30.
7. Frey M, Giovanoli P, Michaelidou M. Functional upgrading of partially recovered facial palsy by cross-face nerve grafting with distal end-to-side neurorrhaphy. *Plast Reconstr Surg.* 2006;117:597–608.
8. Hontanilla B, Marre D. Masseteric-facial nerve transposition for reanimation of the smile in incomplete facial paralysis. *Br J Oral Maxillofac Surg.* 2015;53:943–948.
9. Hontanilla B, Cabello A. Spontaneity of smile after facial paralysis rehabilitation when using a non-facial donor nerve. *J Craniomaxillofac Surg.* 2016;44:1305–1309.
10. Terzis JK, Karypidis D. Outcomes of direct muscle neurotisation in adult facial paralysis. *J Plast Reconstr Aesthet Surg.* 2011;64:174–184.
11. Terzis JK, Tzafetta K. The "babysitter" procedure: Minihypoglossal to facial nerve transfer and cross-facial nerve grafting. *Plast Reconstr Surg.* 2009;123:877–888.
12. Faria JC, Scopel GP, Busnardo FF, Ferreira MC. Nerve sources for facial reanimation with muscle transplant in patients with unilateral facial palsy: Clinical analysis of 3 techniques. *Ann Plast Surg.* 2007;59:87–91.
13. Hontanilla B, Aubá C. Automatic three-dimensional quantitative analysis for evaluation of facial movement. *J Plast Reconstr Aesthet Surg.* 2008;61:18–30.
14. Hontanilla B, Vila A. Comparison of hemihypoglossal-facial nerve transposition with a cross-facial nerve graft and muscle transplant for the rehabilitation of facial paralysis using the facial clima method. *J Plast Surg Hand Surg.* 2012;46:25–31.
15. Hontanilla B, Marré D. Comparison of hemihypoglossal nerve versus masseteric nerve transpositions in the rehabilitation of short-term facial paralysis using the Facial Clima evaluating system. *Plast Reconstr Surg.* 2012;130:662e–672e.
16. Hontanilla B, Marre D, Cabello A. Facial reanimation with gracilis muscle transfer neurotized to cross-facial nerve graft versus masseteric nerve: A comparative study using the Facial Clima evaluating system. 2013;131:1241–1252.
17. Iacolucci CM, Banks C, Jowett N, et al. Development and validation of a spontaneous smile assay. *JAMA Facial Plast Surg.* 2015;17:191–196.
18. Hontanilla B, Qiu SS. Transposition of the hemimasseteric muscle for dynamic rehabilitation of facial paralysis. *J Craniofac Surg.* 2012;23:203–205.
19. Yoshioka N. Masseteric nerve as "baby sitter" procedure in incomplete facial paralysis. *Plast Reconstr Surg Glob Open* 2016;4:e669.
20. Bianchi B, Ferri A, Ferrari S, Copelli C, Salvagni L, Sesenna E. The masseteric nerve: A versatile power source in facial animation techniques. *Br J Oral Maxillofac Surg.* 2014;52:264–269.
21. Coombs CJ, Ek EW, Wu T, Cleland H, Leung MK. Masseteric-facial nerve coaptation: An alternative technique for facial nerve reinnervation. *J Plast Reconstr Aesthet Surg.* 2009;62:1580–1588.

22. Bae YC, Zuker RM, Manktelow RT, Wade S. A comparison of commissure excursion following gracilis muscle transplantation for facial paralysis using a cross-face nerve graft versus the motor nerve to the masseter nerve. *Plast Reconstr Surg.* 2006;117:2407–2413.
23. Manktelow RT, Tomat LR, Zuker RM, Chang M. Smile reconstruction in adults with free muscle transfer innervated by the masseter motor nerve: Effectiveness and cerebral adaptation. *Plast Reconstr Surg.* 2006;118:885–899.
24. Lifchez SD, Matloub HS, Gosain AK. Cortical adaptation to restoration of smiling after free muscle transfer innervated by the nerve to the masseter. *Plast Reconstr Surg.* 2005;115:1472–1479; discussion 1480–1482.
25. Rubin LR, Rubin JP, Simpson RL, Rubin TR. The search for the neurocranial pathways to the fifth nerve nucleus in the reanimation of the paralyzed face. *Plast Reconstr Surg.* 1999;103:1725–1728.
26. Hontanilla B, Marre D. Differences between sexes in dissociation and spontaneity of smile in facial paralysis reanimation with the masseteric nerve. *Head Neck* 2014;36:1176–1180.
27. Elbert T, Rockstroh B. Reorganization of human cerebral cortex: The range of changes following use and injury. *Neuroscientist* 2004;10:129–141.
28. Buendia J, Loayza FR, Luis EO, Celorrio M, Pastor MA, Hontanilla B. Functional and anatomical basis for brain plasticity in facial palsy rehabilitation using the masseteric nerve. *J Plast Reconstr Aesthet Surg.* 2016;69:417–426.