Facial Reanimation with Gracilis Muscle Transfer Neurotized to Cross-Facial Nerve Graft versus Masseteric Nerve: A Comparative Study Using the FACIAL CLIMA Evaluating System

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Background: Longstanding unilateral facial paralysis is best addressed with microneurovascular muscle transplantation. Neurotization can be obtained from the cross-facial or the masseter nerve. The authors present a quantitative comparison of both procedures using the FACIAL CLIMA system.

Methods: Forty-seven patients with complete unilateral facial paralysis underwent reanimation with a free gracilis transplant neurotized to either a cross-facial nerve graft (group I, $n = 20$) or to the ipsilateral masseteric nerve (group II, $n = 27$). Commissural displacement and commissural contraction velocity were measured using the FACIAL CLIMA system. Postoperative intragroup commissural displacement and commissural contraction velocity means of the reanimated versus the normal side were first compared using the independent samples *t* test. Mean percentage of recovery of both parameters were compared between the groups using the independent samples *t* test.

Results: Significant differences of mean commissural displacement and commissural contraction velocity between the reanimated side and the normal side were observed in group I ($p = 0.001$ and $p = 0.014$, respectively) but not in group II. Intergroup comparisons showed that both commissural displacement and commissural contraction velocity were higher in group II, with significant differences for commissural displacement ($p = 0.048$). Mean percentage of recovery of both parameters was higher in group II, with significant differences for commissural displacement ($p = 0.042$).

Conclusions: Free gracilis muscle transfer neurotized by the masseteric nerve is a reliable technique for reanimation of longstanding facial paralysis. Compared with cross-facial nerve graft neurotization, this technique provides better symmetry and a higher degree of recovery. (*Plast. Reconstr. Surg.* 131: 1241, 2013.)

CLINICAL QUESTION/LEVEL OF EVIDENCE: Therapeutic, III.

Reanimation of the paralyzed face depends on a number of factors, of which time of denervation is one of the most relevant. Thus, in patients with longstanding paralysis (i.e., >2 years) in whom there is no viable facial musculature, a new muscle unit must be incorporated to restore motion, which can be either regional or distant.[1–3]

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Neurovascular gracilis transfer has been long used for dynamic smile restoration,[4] with different options of neurotization.[5] The contralateral facial nerve by means of cross-face nerve grafting is an established technique in unilateral facial paralysis to achieve a coordinated and spontaneous smile.[6] However, in patients without a suitable contralateral facial nerve (bilateral facial paralysis, Möbius syndrome), or who do not wish to have two operations, or who have strong smile on the normal side, the motor nerve to the masseter muscle can be used with good results.[7–10]

One of the critical issues when comparing different techniques for dynamic reanimation of facial paralysis is the measurement system used. Traditionally, the House-Brackmann scale has been used[11]; however, it has the problem that it assesses the degree of facial paralysis in qualitative terms and is an observer-dependent method. Other systems have been described, but none has been accepted for clinical use so far.[12–14] In 2008, we developed an automatic, reproducible, easy, fast, quantitative method called FACIAL CLIMA, which provides dynamic three-dimensional information that allows comparison of results obtained after reanimation with different techniques.[15,16] The objective of this study is to compare commissural displacement and velocity of muscle contraction of free gracilis transfer neurotized to either cross-facial nerve grafting or masseteric nerve, using the FACIAL CLIMA system.

PATIENTS AND METHODS

From 2000 to 2010, 68 patients with complete, long-term (i.e., >2 years) unilateral facial paralysis underwent reanimation with gracilis muscle transfer neurotized either to a cross-face nerve graft ($n = 41$) or to the ipsilateral masseteric nerve ($n = 27$). Because neurotization with the masseteric nerve has been performed since 2005, we included cases from this year on for both techniques. Thus, a total of 47 patients were studied, with 20 in group I and 27 in group II. Selection of surgical technique was decided on an individual basis and not randomly. In general terms, for patients with a strong full smile and who accept the fact of having to bite to smile during a variable period of time, the masseteric nerve was preferred. Conversely, for patients with softer smiles and/or who do not wish to have neurotization by means of a nonfacial nerve, cross-facial nerve grafting was performed. All operations were performed by the senior author (B.H.). For all patients, sex, cause of disease, age at surgery, time of evolution of paralysis, and follow-up were registered. In addition, for patients neurotized by means of cross-facial nerve grafting, the interval (days) between the first and second operations was registered. In all cases, a complete evaluation including physical examination, standard photographs and video, electromyography, and FACIAL CLIMA was conducted preoperatively and 3, 6, 12, and 24 months after surgery. Complete paralysis was defined as the absence of clinical movement on both physical examination and FACIAL CLIMA and no signs of recovery on needle electromyography.

Gracilis Transfer Neurotized to Cross-Facial Nerve Graft

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 in the posterolateral leg, connected reversely and tunneled subcutaneously all the way to the contralateral modiolus. Mean length of nerve graft was 20 cm (range, 18 to 22 cm).

Second Stage

Once Tinel's sign is noted (mean, 239 days in our series), the second stage is planned. Through a preauricular incision on the paralyzed side, dissection is carried out all the way to the modiolus, where the nerve graft is identified. Next, the desired vector of pull (previously determined by the contralateral smile) is simulated with three to five Ethibond 2-0 sutures (Ethicon, Inc., Somerville, N.J.). Simultaneously, a segment of gracilis muscle is harvested as described elsewhere.[17] The flap is then transferred to the face and fixed to the modiolus and zygomatic arch. Vascular microanastomoses to the facial vessels and coaptation to the cross-facial nerve graft is then performed.

Gracilis Transfer Neurotized to the Masseteric Nerve

Through a preauricular incision on the paralyzed side, the masseter muscle is exposed and partially released below the zygomatic arch. The motor nerve is located 4 cm anterior to the tragus and 2 cm below the zygomatic arch. This nerve has a pattern of arborization to innervate the masseter muscle on its undersurface.[18] Thus, by dividing the nerve distal to some of its first side branches, the muscle is only partially denervated without reducing the axonal load of the distal stump that is coapted to the obturator nerve of the gracilis muscle. The gracilis muscle is harvested and anchored as described above. The rest of the procedure is exactly the same as above. It is important to note that no functional deficit is observed after partial sacrifice of the masseteric nerve.

Rehabilitation Protocol

Patients are asked to start training 1 month after surgery. Biofeedback rehabilitation in front of a mirror for at least 10 minutes per day is recommended. No formal physical therapy or other methods (e.g., neuromuscular retraining, electric stimulation) are indicated. During this period and until movement is observed, patients with masseteric neurotization are told to move the reconstructed side by teeth clenching. Once motion is restored in these patients, training consists of attempting to smile by triggering the donor nerve's original action but completing smile independently from it.

Description of the Capture System: FACIAL CLIMA

FACIAL CLIMA is an automatic optical system to capture facial movements, which involves placing special reflecting dots on the subject's face following a predetermined configuration. A system of video recording with three infrared-light cameras captures the subject performing the following movements: smiling, mouth puckering, eye closure, and forehead elevation. With these four movements, several vectors are obtained and analyzed. (**See Video, Supplemental Digital Content 1,** which shows The FACIAL CLIMA system recording with three infrared-light cameras that capture the subject performing the following movements: smiling, mouth puckering, eye closure, and forehead elevation. With these four movements, several vectors are obtained and analyzed, ***http://links.lww.com/PRS/A723***.) Images from the cameras are automatically processed by computer software that generates customized information such as three-dimensional data on velocities, distances, and areas. The accuracy of the measurement process is between 0.13 mm and 0.41 degree. This system has been tested in normal patients and found to have a reliability of 99 percent. For more information about intrarrater and interrater accuracy and exact functioning of this system, see Hontanilla and Aubá.[15]

Video 1. Supplemental Digital Content 1 shows The FACIAL CLIMA system recording with three infrared-light cameras that capture the subject performing the following movements: smiling, mouth puckering, eye closure, and forehead elevation. With these four movements, several vectors are obtained and analyzed, ***http://links.lww.com/PRS/A723***.

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 (in millimeters per second) (mean of maximum velocity of contraction) and oral commissure displacement (in millimeters) (mean difference between the maximum and minimum commissural distance at rest and when contracted). Both parameters were obtained from the normal and reanimated sides. Patients were analyzed 2 years after surgery. Because all patients presented with complete paralysis, both commissural contraction velocity and commissural displacement were 0 in the preoperative situation. First, to evaluate the degree of symmetry obtained with each technique, intragroup comparison of commissural displacement and commissural contraction velocity of the reanimated compared with the normal side of each patient was conducted. 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. With this, each subject is compared with himself or herself, avoiding biased comparisons between different individuals (i.e., a patient with a strong full smile compared with another with a soft lateral smile). Finally, the mean percentage of recovery of commissural displacement and commissural contraction velocity was obtained for each technique.

For intergroup comparisons, the Levene test for equality of variances was conducted first. Next, all quantitative variables (i.e., age, time of evolution, commissural displacement, commissural contraction velocity, and percentage of recovery) were compared using the two-sample t test. Gender proportions were compared using the chi-square test. For intragroup analysis of commissural displacement and commissural contraction velocity (i.e., comparison of normal side with reanimated side), the paired-sample t test was used. Finally, mean percentage of recovery of men and women of both groups were compared, and multiple linear regression was conducted to analyze the possible influence of age, denervation time, and surgical technique on percentage of recovery of commissural displacement and commissural contraction velocity for the whole sample. SPSS v17.0 (SPSS, Inc., Chicago Ill.) was used to analyze results and perform all statistical tests, setting significance at $p < 0.05$.

RESULTS

Patients demographics of both groups are listed in Table 1. Groups were comparable regarding sex, age, time of evolution, and follow-up (Table 1). The cause of paralysis is summarized in Table 2. As we have selected patients with complete facial paralysis, preoperative measurements of the paralyzed side in all cases showed neither movement nor electrical activity of the oral commissure.

In group I (cross-facial nerve grafting), the mean oral commissure displacement 2 years after surgery was 8.4 ± 3.1 mm on the healthy side and 5.1 ± 2.6 mm on the reanimated side ($p = 0.001$). Mean postoperative commissural contraction velocity was 33.3 ± 11.9 mm/second on the healthy side and 23.8 ± 12.8 mm/second on the reanimated side ($p = 0.014$) (Table 3).

Table 1. Patient Demographics*

	Surgical Technique		
Variable	**CFNG**	**Masseteric**	***p***
No.	20	27	
Male	7	12	0.66
Female	13	15	
Mean ± SD age, yr	42.4 ± 10.1	40.7 ± 13.8	0.71
Evolution, mo			0.82
Mean ± SD	121.7 ± 157.8	108.4 ± 152.4	
Median	60	45.5	
Mean ± SD follow-up, mo	38.4 ± 15.7	33.2 ± 12.2	0.12

CFNG, cross-facial nerve graft.
*Chi-square test shows no significant differences in sex distribution between the groups.
Similarly, the t test shows no significant differences for the rest of the variables.

Table 2. Cause of Paralysis

	Surgical Technique	
Cause	**CFNG**	**Masseteric**
Acoustic neurinoma	7	11
Posterior fossa tumor	2	6
Traumatic	3	4
Congenital/obstetric	3	2
Facial neuroma	0	2
Ear surgery	2	2
Varicella zoster	2	0
Bell palsy	1	0
Total	20	27

CFNG, cross-facial nerve graft.

In group II (masseteric), the mean oral commissure displacement 2 years after surgery was 9.1 ± 3.4 mm on the healthy side and 7.7 ± 2.8 mm on the reanimated side ($p = 0.41$). Mean postoperative commissural contraction velocity was 35.4 ± 13.8 mm/second on the healthy side and 31.3 ± 15.1 mm/second on the reanimated side ($p = 0.67$) (Table 3).

For intergroup comparisons, the Levene test for equality of variances showed no statistical significance for any of the variables analyzed (i.e., commissural displacement, commissural contraction velocity, and percentage of recovery). Comparison of commissural displacement of the reanimated side showed significant differences, with higher excursion in group II (5.1 versus 7.7, $p = 0.048$). Comparison of commissural contraction velocity was also higher in group II but not statistically significantly so (23.8 versus 31.3, $p = 0.29$). Similarly, percentage of recovery of both parameters was higher in group II, with a significant difference for commissural displacement (61.1 versus 90.6, $p = 0.042$) but not for commissural contraction velocity (73.2 versus 94.7, $p = 0.33$) (Table 4).

Mean percentage of recovery of men compared with women was not significantly different in either group ($p > 0.05$). Moreover, multiple linear regression revealed a significant impact of surgical technique over percentage of recovery of commissural displacement (coefficient, −0.81; $p = 0.02$). The effect over recovery of velocity was also important, although it did not reach statistical significance (coefficient, −0.76; $p = 0.06$) (Table 5). (**See Video, Supplemental Digital Content 2,** FACIAL CLIMA showing the preoperative study of the patient in Figure 1, ***http://links.lww.com/PRS/A724***; and **See Video, Supplemental Digital Content 3,** FACIAL CLIMA showing the postoperative study of the patient in Figure 1, ***http://links.lww.com/PRS/A725***.) (Figs. 2 through 4).

Table 3. Intragroup Comparison of Commissure Displacement and Commissure Contraction Velocity

	Mean ± SD CD (mm)			Mean ± SD CCV (mm/second)		
Group	**Healthy**	**Reanimated**	***p***	**Healthy**	**Reanimated**	***p***
I (CFNG)	8.4 ± 3.1	5.1 ± 2.6	0.001	33.3 ± 11.9	23.8 ± 12.8	0.014
II (masseteric)	9.1 ± 3.4	7.7 ± 2.8	0.41	35.4 ± 13.8	31.3 ± 15.1	0.67

CD, commissural displacement; CCV, commissural contraction velocity; CFNG, cross-facial nerve graft.

Table 4. Intergroup Comparison of Commissure Displacement and Commissure Contraction Velocity

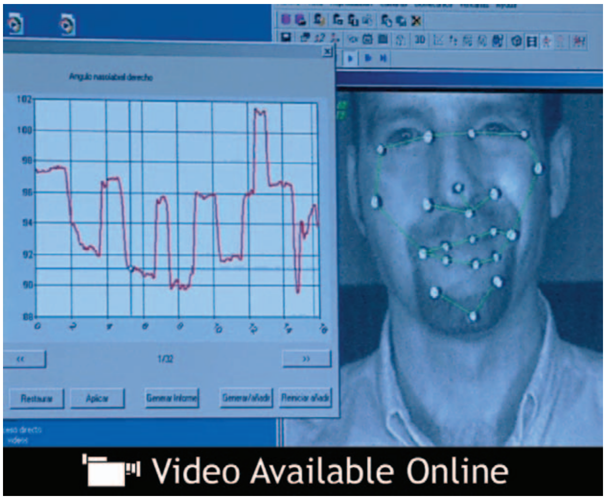
	Healthy Side*		Reanimated Side*		Recovery (%)*	
Group	**CD (mm)**	**CCV (mm/second)**	**CD (mm)**	**CCV (mm/second)**	**CD**	**CCV**
I (CFNG)	8.4 ± 3.1	33.3 ± 11.9	5.1 ± 2.6	23.8 ± 12.8	61.1 ± 25.6	73.2 ± 32
II (masseteric)	9.1 ± 3.4	35.4 ± 13.8	7.7 ± 2.8	31.3 ± 15.1	90.6 ± 32.7	94.7 ± 26.6
p	0.69	0.75	0.048	0.29	0.042	0.33

CD, commissural displacement; CCV, commissural contraction velocity; CFNG, cross-facial nerve graft.
*Mean ± SD.

Table 5. Multiple Linear Regression to Analyze the Influence of Age and Denervation Time on Recovery of Commissure Excursion and Velocity*

Parameter	Age	Denervation Time	Reanimation Technique
Percentage excursion recovery			
Coefficient	0.45	−0.38	−0.81
p	0.1	0.97	0.02
Percentage velocity recovery			
Coefficient	0.62	0.16	−0.76
p	0.13	0.54	0.06

*Note that although no significant correlation is seen with age and denervation time, surgical technique does have a significant impact on recovery of commissural excursion (coefficient, −0.81; $p = 0.02$). The effect over recovery of velocity is also important, although it does not reach statistical significance (coefficient, −0.76; $p = 0.06$).



Video 2. Supplemental Digital Content 2 is FACIAL CLIMA showing the preoperative study of the patient in Figure 1, ***http://links.lww.com/PRS/A724***.

DISCUSSION

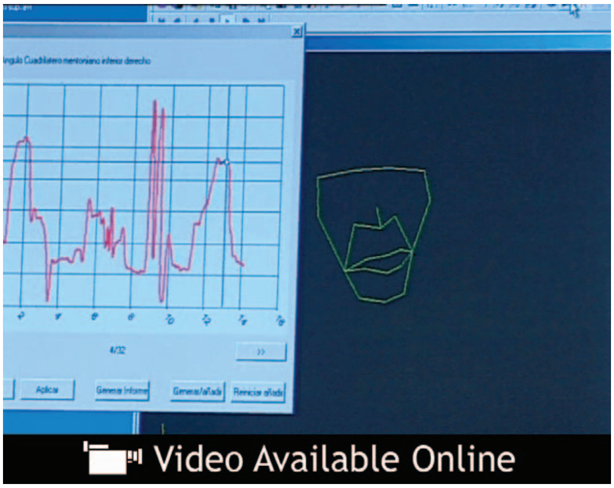
Selection of the correct technique to reanimate a paralyzed face has been the cornerstone of facial paralysis surgery ever since. Today, considering the variety of procedures available, probably one of the most challenging aspects of facial reanimation is actually indicating the right technique for the right patient. Efforts to compare different reanimation techniques have already been conducted by several authors.[5,10,16,19–21] Regarding neurotization of free gracilis transfer, Bae et al. conducted a comparative study of cross-facial nerve grafting versus masseteric nerve in children. In their work, the authors conclude that with the masseteric nerve, greater commissural excursion and symmetry are achieved, suggesting that such technique provides a commissure excursion in the range of normal.[10]

Free gracilis transfer innervated by means of cross-facial nerve grafting is currently an established technique for reanimation of complete longstanding facial palsy. The main advantages of this technique include the ability to restore a smile that is spontaneous and coordinated with the contralateral side. Nevertheless, the technique does have some disadvantages. First, two stages are required. Even though some authors have advocated a one-stage procedure,[22] we, as do most surgeons, still prefer the two-stage approach, because leaving the transplanted muscle denervated while the axons cross the nerve graft may result in partial atrophy affecting the final outcome. Second, neurotization by means of cross-facial nerve grafting needs a donor nerve (in our series, the sural nerve was used in all patients), which carries some morbidity, although this is well tolerated by most patients. Third, when a nerve graft is used, the axons must cross two sites of coaptation, which may result in suboptimal reinnervation of the target muscle.[23,24] Last, and probably as a consequence of the above,

Fig. 1. A 40-year-old man with right facial paralysis secondary to acoustic neurinoma resection 8 years previously. (*Above*, *left*) Preoperatively at rest and (*above*, *right*) when smiling. A gracilis muscle transplant connected to a cross-facial nerve graft was performed. (*Below*, *left*) The patient 2 years postoperatively at rest and (*below*, *right*) when smiling.

commissure excursion with this technique may not be adequately restored, resulting sometimes in an asymmetrical movement (in quantitative terms) compared with the contralateral normal side.[10]

The masseteric nerve has been used successfully for rehabilitation of the paralyzed face for the past two decades, with very good functional and aesthetic results. Not surprisingly, a considerable number of studies have been published regarding its anatomy and topographic landmarks to aid in its harvest for facial reanimation.[18,25,26] Moreover, the motor nerve to the masseter has been used not only to innervate a free muscle transfer but also as a nerve transposition and "babysitter" following



Video 3. Supplemental Digital Content 3 is FACIAL CLIMA showing the postoperative study of the patient in Figure 1, ***http://links.lww.com/PRS/A725***.

the concept described by Mersa et al.[27–29] 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.[10,30] 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.[30] Furthermore, with this technique, the unaffected side is preserved, only one stage is required, and no nerve grafts are used, which implies that during reinnervation the axons must cross only one site of coaptation.

For patients with complete paralysis, an option of reanimation, apart from free gracilis transfer, could be temporalis muscle transposition either as a turnover flap or as a lengthening myoplasty.[3,31–33] This technique provides adequate excursion, needs triggering as with masseteric neurotization, and does not rely on microsurgical anastomoses. During recent decades, this technique has evolved greatly; however, despite the improvements made, in our opinion there are several issues that still need to be considered. The bulge produced in the cheek region with the turnover technique can sometimes be a problem, even with "excessive" muscle stretching and malar fat pad resection. Besides, by stretching the muscle to its limits, there is a greater risk of muscle detachment from the corner of the mouth. Thinner strips of muscle and the lengthening myoplasty have been described to overcome this problem.[3,34] With the latter, the bulge is reduced significantly but at the expense of performing an osteotomy and repair of the zygomatic arch, which adds morbidity and postoperative edema that takes time to resolve. Also important are the facial incisions in the nasolabial fold and vermillion,[3,34] which should be seriously considered, especially in women. Furthermore, some authors advocate using a fascia lata extension for anchoring, which creates another scar on the thigh. The fact that temporalis regional transfer does not rely on microsurgery may be considered an advantage; however, with the growing use of microsurgical techniques in different fields of plastic surgery and the advances seen during recent decades, this is no longer the case. Thus, in our institution, as do other authors,[35,36] we usually offer the possibility of a temporalis transfer as a first choice to older patients who are not candidates for a free muscle transfer, patients with a poor prognosis, those who desire less invasive surgery and short recovery, and also those patients with residual asymmetry after a neurotization procedure. Another alternative could be the one-stage latissimus dorsi flap. This flap provides a symmetrical and synchronous smile with the normal side.[36,37] In our institution, we have performed reanimation mostly with the gracilis muscle during the past 12 years and feel much more comfortable with this. Besides, although the latissimus dorsi flap has the advantage of a one-stage procedure over the gracilis neurotized to a cross-facial nerve graft, this is not the case for neurotization by means of the masseteric nerve. With the latter, a synchronous smile can eventually be obtained after training and, in our opinion, produces less donor-site morbidity, as the scar is inconspicuous and there are seldom complications such as seroma, which are relatively frequent with the latissimus dorsi flap. Furthermore, despite using the facial nerve for neurotization, we have seen that with one-stage latissimus dorsi flap surgery, spontaneity is not always achieved, as this is commanded by neural pathways different from those of voluntary smiling.

In the present work, we have observed significantly better outcomes of symmetry, commissure excursion, and velocity in the group of patients with gracilis innervated by the motor nerve to the masseter. In an initial analysis, to assess the degree of symmetry achieved with each technique, we compared the postoperative means of commissural displacement and commissural contraction velocity of the reanimated versus the normal side within each group. Statistical differences for commissural displacement and commissural contraction velocity were observed in group I (cross-facial nerve grafting) but not in group II (masseteric),

Fig. 2. A 53-year-old woman with right facial paralysis secondary to acoustic neurinoma resection 10 years previously. Some type of static suspension was performed 5 years after the onset of facial paralysis. (*Above*, *left*) Preoperatively at rest and (*above*, *left*) when smiling. A gracilis muscle transplant connected to a cross-facial nerve graft was performed. (*Below*, *left*) The patient 1 year postoperatively at rest and (*below*, *right*) when smiling.

suggesting that with the latter a movement more similar to the normal side is obtained. In a 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, to avoid bias from the heterogeneity of smiles, for each procedure we compared the average percentage of recovery of the paralyzed side in relation to the normal side. Patients with a cross-facial nerve graft recovered a mean of 61.1 percent of commissural displacement compared with the contralateral side, whereas patients with masseteric neurotization showed a mean recovery of 90.6 percent ($p = 0.042$). Commissural contraction velocity recovery was also higher in group II, although statistical significance was not reached.

The main drawbacks of using the masseteric nerve for smile reanimation are that the restored

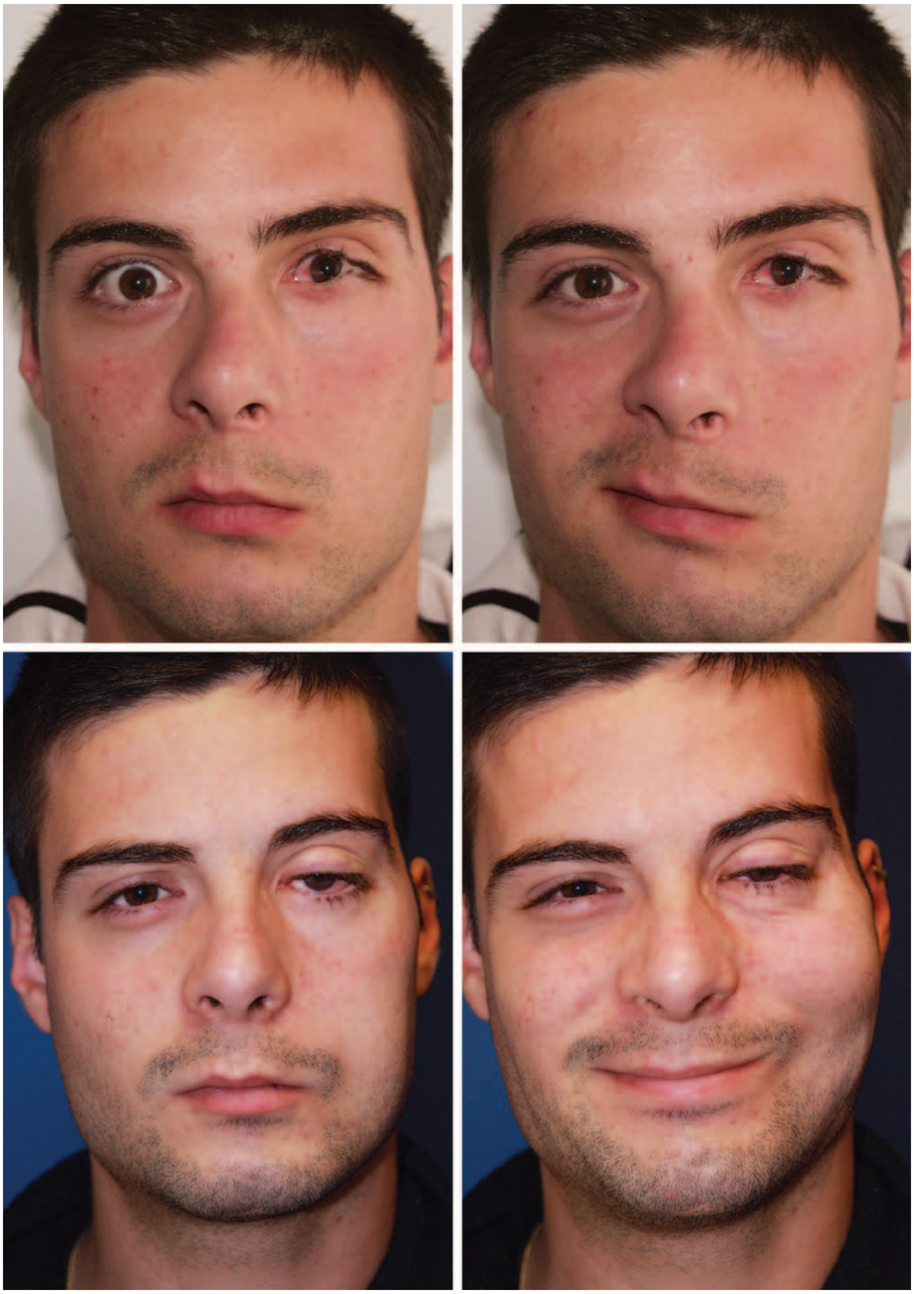


Fig. 3. A 26-year-old man with left facial paralysis secondary to a brainstem tumor resection 5 years previously. (*Above*, *left*) Preoperatively at rest and (*above*, *right*) when smiling. A gracilis muscle transplant connected to the masseteric nerve was performed. (*Below*, *left*) The patient 2 years postoperatively at rest and (*below*, *right*) when smiling.

movement is triggered by teeth clenching, and smiling is not spontaneous. Regarding the former, we have observed that, with training, approximately 12 to 18 months after surgery, most patients learn to dissociate the movement of smiling from biting, thus achieving an open mouth smile. Spontaneity, however, seems harder to restore, as it has to do with the ability to smile involuntarily in response to a hilarious 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 "dissociated" and spontaneous smile after reanimation with the masseteric nerve or with temporalis muscle transposition.[7,35,38,39] Both dissociation and spontaneity require some degree of

Fig. 4. A 27-year-old man with left facial paralysis secondary to a widespread neurofibromatosis resection 6 years previously. (*Above*, *left*) Preoperatively at rest and (*above*, *right*) when smiling. A gracilis muscle transplant connected to the masseteric nerve was performed. (*Below*, *left*) the patient 2 years postoperatively at rest and (*below*, *right*) when smiling.

cortical plasticity to develop, for which motivation and training play a key role.[40–42] Further functional imaging studies will surely shed some light on the intricate process that takes place in the brain after facial reanimation with nonfacial nerves. Another potential disadvantage of masseteric neurotization is the possibility of temporary "synkinetic" movements of the reanimated side while chewing food. However, in our experience, patients normally do not complain much of this effect. If it appears, it is usually not disturbing and disappears within a few months after surgery. Besides, while chewing food, one performs several mouth and cheek movements and not only jaw clenching. In addition, most individuals have some degree of lateral preference in mastication.[43,44] In cases of facial paralysis, chewing is performed mostly on the unaffected side. Such preference is likely to remain after reanimation and may partly explain why the presence, if any, of such movements is well tolerated and self-limited.

An important aspect of our study is the method used to assess our postoperative results. In 2008, we introduced the FACIAL CLIMA, an automatic, quantitative, operator-independent, objective method that allows dynamic quantification of facial movements. Even though smile anatomy comprises several vectors and parameters, for the purpose of this work we focused mainly on commissural excursion for two main reasons: first, commissural or modiolar movement are both frequently used to assess outcomes in facial reanimation[10,45]; and second, it must be considered that the patients included here have complete paralysis reanimated with a gracilis muscle transfer, which provides mainly restoration of an oblique vector from the commissure to the zygomatic arch with little or no vertical movement. Thus, by analyzing commissural displacement (in millimeters) and commissural contraction velocity (in millimeters per second), it is possible to evaluate the degree of symmetry obtained by comparing the reanimated and the normal sides, and to assess the degree of recovery by calculating the percentage of recovery considering the healthy side as the reference. This is an important aspect to consider when comparing different techniques of facial reanimation. Because smiles are different between individuals, comparing only the absolute value of each parameter is not entirely accurate. For example, a patient with a strong smile can have a higher value of commissural displacement than someone with a "weak" smile, without meaning that the latter has some form of paralysis. This is why we sought to compare the percentage of recovery of each individual in relation to his or her normal side. The mean obtained from these percentages is a much more realistic indicator of the actual efficacy of the reanimation technique, making comparisons between procedures possible.

CONCLUSIONS

In conclusion, these results indicate that free gracilis transfer neurotized to the masseteric nerve is a reliable technique of smile reanimation with which a high degree of symmetry and functional recovery can be obtained. Even though spontaneity cannot be guaranteed, further investigations of the cortical rearrangements following reanimation with this method will help us understand the intricate process that takes place and possibly give us some insight into how to improve our outcomes regarding restoration of a natural smile.

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PATIENT CONSENT

Patients provided written consent for the use of their images.

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