Differences between sexes in dissociation and spontaneity of smile in facial paralysis reanimation with the masseteric nerve

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ABSTRACT: *Background.* A patient's sex is likely to play an important role in facial paralysis reanimation, with women being superior in terms of development of brain plasticity after reanimation. The purpose of this study was to compare the rate of movement dissociation and spontaneity of men versus women reanimated with gracilis transfer neurotized to the masseteric nerve.

Methods. We conducted a retrospective chart review of 27 patients who underwent facial paralysis reanimation with microvascular gracilis transplants neurotized to the ipsilateral masseteric nerve. Patients were classified by sex, comparing age at surgery, denervation time, and follow-up, as well as the rates of movement dissociation and smile spontaneity.

Results. After reanimation with gracilis to masseteric nerve, movement dissociation and spontaneity were higher in women during the first year after onset of facial movement ($p = .02$ and $p = .01$, respectively).

Conclusion. After reanimation with masseteric nerve, women seem to be able to smile spontaneously and independently from teeth clenching earlier than men. © 2013 Wiley Periodicals, Inc. *Head Neck* **36:** 1176–1180, 2014

KEY WORDS: facial paralysis, gender, muscle transplant, nerve transfer

INTRODUCTION

Facial paralysis represents a challenging topic in reconstructive surgery. During the last decades, different surgical procedures have been described,[1–3] with various authors reporting very good functional and aesthetic results.[4–7] Despite minor variations among different surgeons in the application and timing of the different techniques available, some basic concepts must be considered when dealing with facial paralysis. Such concepts have little to do with the surgeon's preference or experience, but instead are related to nerve degeneration/regeneration processes and muscle denervation and atrophy. Thus, for smile restoration, most authors agree that when the proximal ipsilateral stump is unavailable, the contralateral facial nerve can be used as donor nerve via cross-face nerve grafting (CFNG) as the only treatment, provided that denervation time is no more than 3 months.[8] For patients with paralysis between 3 months and 2 years of evolution, Mersa et al[9] introduced the "baby sitter" procedure, in which an ipsilateral nerve (ie, hypoglossal nerve) is partially sacrificed in order to innervate the facial musculature whereas the contralateral noninjured facial nerve axons reach the paralyzed side through a CFNG. Direct neurotizations via masseteric nerve, hypoglossal nerve, a segment of the ipsilateral C7 root, or part of the accessory nerve are also possibilities for reconstruction in this group of patients.[10,11] Finally, if the time since the injury is >2 years, a new muscle unit must be transferred and neurotized either by the contralateral facial nerve via CFNG or an ipsilateral motor nerve (ie, masseteric nerve or hypoglossal nerve). It is important to note that although the use of the contralateral noninjured facial nerve achieves harmonious, coordinated, and synchronous movements with the normal side, contraction is often weak.[12] By contrast, with ipsilateral nerves, contraction is much stronger, but coordination is very difficult to achieve, especially in adults, and intensive training is mandatory. Our general protocol in secondary facial paralysis reconstruction is presented in Figure 1.

Throughout our experience in facial paralysis reanimation, we have seen that in cases of neurotization via masseteric or hypoglossal nerve, women learn to dissociate the movement of smile from the one that the cranial nerve was originally serving much better than men do (ie, smile without biting or without pressing the tongue against the incisor teeth). Following these observations, the purpose of the present study was to compare the rate of movement dissociation and smile spontaneity between men and women after facial paralysis reanimation with free gracilis transplant neurotized to the masseteric nerve.

PATIENTS AND METHODS

Between 1999 and 2011, 66 microvascular gracilis transplants were performed (39 neurotized to the contralateral facial nerve via CFNG and 27 neurotized to the ipsilateral masseteric nerve). All patients were operated

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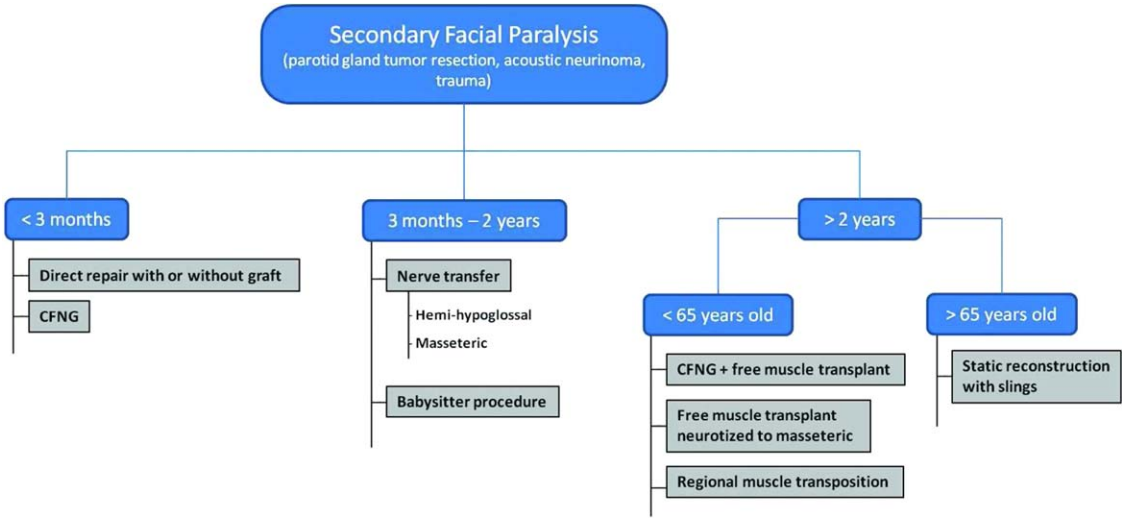

FIGURE 1. Treatment algorithm for secondary facial paralysis. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

on by the senior author (B.H.). No complications requiring surgical intervention or antibiotic administration beyond prophylaxis were registered. In order to make our study population as homogeneous as possible for comparison of movement dissociation and spontaneity, only patients reanimated with free gracilis neurotized to masseteric nerve were studied. Patients were classified according to sex, and the following variables were registered: age at surgery, etiology of paralysis, time of evolution, and follow-up in all cases. Dissociation and spontaneity were also registered. Movement dissociation was defined as the ability to smile independently from jaw closure and was assessed clinically. Spontaneity was defined as the presence of an effortless smile in response to a funny comment made by the physician during follow-up visits. All patients were evaluated by physical examination, standard photographs and video, and electromyography. Commissure excursion (CE in mm) and commissure contraction velocity (CCV in mm/s) of both the paralyzed and healthy sides were registered as well using the FACIAL CLIMA.[13] Postoperative follow-up visits were conducted by at least 1 of the authors and scheduled 3, 6, and 12 months after surgery, and then once a year. Movement dissociation was evaluated and documented at least 1 year after surgery and was done by asking the patient to smile with an open mouth. In each follow-up visit, CE and CCV of the reanimated side were also registered. All patients, irrespectively of sex, were instructed to train the movement of smile during 10 minutes daily starting 2 weeks after surgery.

Quantitative variables were analyzed using the Mann–Whitney *U* test. Comparison between sexes of movement dissociation and spontaneity was conducted using Fisher's exact test. SPSS v17.0 (SPSS, Chicago, IL) was used to analyze results and perform all statistical tests, setting significance at $p < .05$.

RESULTS

Of the 27 patients included in this study, 15 were women and 12 men. Mean age at surgery was 43.2 ± 5.6 and 40.3 ± 6.1 years, respectively, without significant differences between them ($p = .54$). Likewise, time of denervation was similar, with 33.7 ± 4.1 months in women and 30.8 ± 5.5 months in men ($p = .73$). Mean time of follow-up also did not differ significantly between the groups ($p = .81$; Table 1). Needle electromyography showed no activity in terms of amplitude and conduction velocity, confirming complete paralysis in all patients. Postoperatively, all patients performed the physical therapy protocol indicated by the physician.

Analysis of the ability to dissociate the movement of smiling and biting showed a significantly higher rate of movement dissociation in women ($p = .02$; Table 2). Likewise, women also showed significantly higher rates of smile spontaneity ($p = .01$). Comparison of CE and CCV between sexes showed no statistical differences (Table 3).

Case examples

Case of masseteric neurotization. A 46-year-old woman underwent facial neuroma surgery 3 years before resulting in a complete right facial paralysis (Figure 2). She consulted us for reanimation showing right frontal paralysis, lagophthalmos, lower eyelid ptosis, no CE, and a competent masseter muscle. The patient underwent free gracilis

TABLE 1. Comparison between sexes of age, time of evolution, and follow-up of patients included in the group.

Surgical technique	No. of women	No. of men	*p* value
Free gracilis to masseteric nerve	15	12	
Age, y (mean ± SD)	43.2 ± 5.6	40.3 ± 6.1	.54
Time, mo (mean ± SD)	33.7 ± 4.1	30.8 ± 5.5	.73
Follow-up, mo (mean ± SD)	12.3 ± 6.8	15.4 ± 4.8	.81

Mann–Whitney *U* test shows no significant differences between men and women regarding the different variables.

TABLE 2. Comparison between sexes of movement dissociation and spontaneity of smile in patients reanimated using the masseteric nerve.

Reanimation technique	Women $n = 15$	Men $n = 12$	p value
Gracilis neurotized to masseteric			
Movement dissociation, n (%)	11 (73.3)	3 (25)	.02
Smile spontaneity, n (%)	9 (60)	1 (8.3)	.01

Fisher's exact test shows significantly higher rates of dissociation and spontaneity in women.

muscle transplant neurotized to the masseteric nerve for smile reanimation. No postoperative complications were registered. One year after surgery, spontaneous smile was observed (Video 1, supporting information, online only).

Case of bilateral masseteric neurotization. A 27-year-old man presented a brain stem tumor. After removal of the tumor, a bilateral facial paralysis occurred (Video 2, supporting information, online only). Bilateral gracilis transplant connected to both masseteric nerves was carried out 5 years after the onset of facial paralysis. No postoperative complications were registered. One year after surgery, bilateral CE was detected, but a spontaneous and open mouth smile was not noted (Video 3, supporting information, online only). However, 4 years after the onset of facial movement, spontaneous and dissociation of smile was observed (Video 4, supporting information, online only).

DISCUSSION

Facial expression is a complex process that results from the coordinated and balanced action of the 17 paired muscles of the face. Moreover, when such process is involuntary, neural, psychological, and behavioral factors are added, making it even more intricate. Thus, full restoration of spontaneous, harmonious, and synchronous smile in unilateral secondary facial palsy is at least very difficult to achieve. Even though several factors must be considered,[12] probably the ones that most influence the reconstructive strategy in secondary facial paralysis are facial muscle denervation time and motor unit activity. These features provide the key in ours and other authors' algorithm for facial paralysis reanimation (Figure 1).[10,12,14,15] Notwithstanding the major importance that time of evolution has in the selection of the procedure, our clinical observation has led us to pay attention to another factor influencing our postoperative long-term results, namely sex. The concept of sexual dimorphism in facial paralysis reanimation has been recently published by our team and, in our opinion, is further supported by the current study.[16]

The ability of the human brain to reorganize its functional structure in response to environmental stimuli is, in general terms, what we know today as neural plasticity.[17] Despite its key role, with training alone, brain plasticity does not ensue. Jenkins et al[18] and Elbert et al[19] have suggested that an afferent input in order to enable cortical reorganization has to be intense and must also have some intrinsic function, that is, behavioral relevance. In other words, mere training of a specific action is not enough; use-dependent cortical reorganization requires a high motivational drive because it emerges in response to massed practice of behavioral relevant tasks.[20] In facial paralysis reanimation with nerves other than the facial, these concepts play an important role. In these situations, although good contraction is obtained, intensive training is required and a coordinated, harmonious, and synchronous smile is difficult, albeit possible to achieve. Rubin et al,[21] using relocated halves of temporalis and masseter muscles to reanimate 200 paralyzed faces, demonstrated that most, if not all, paralytic faces would eventually smile spontaneously without clenching their teeth. Moreover, Manktelow et al[22] reported on spontaneous smile occurring routinely in 59% and occasionally in 29% of patients after 45 free-muscle transplants connected to the masseteric nerve for unilateral facial paralysis. Eighty-five percent of patients learned to smile without biting. Age did not affect the degree of spontaneity of smiling or the patient's ability to smile without biting. In this series, no sex differences were studied related to dissociation of movement and spontaneity of smile.

Previous studies have already suggested that women are more prone to develop brain plasticity and consequently benefit more from training than men. Tsuji et al[23] in their work on the benefits of rehabilitative training after neonatal hypoxia-ischemia in rats, found that women benefited from training significantly more than men. In the clinical setting, Lifchez et al[24] reported on 2 cases of unilateral facial paralysis, in which several years after free gracilis transfer innervated by the masseteric nerve, smile independent of jaw closure was achieved. Interestingly, both cases were girls, whereas the third patient reported, a boy, showed inability to smile without biting. In our experience, we have seen that a significantly higher rate of movement dissociation and smile spontaneity is seen in the female population 1 year after the onset of movement. Figure 2 is a good illustration. In this patient, a free-muscle transfer neurotized to the masseteric nerve was performed. With training, 1 year after surgery, she achieved a spontaneous and an open-mouth smile. Video 4 (supporting information, online only), on the other hand, shows a man with a dissociated and spontaneous smile 4 years after the onset of movement. Remarkably, along the previous

TABLE 3. Comparison of commissure excursion and commissure contraction velocity between sexes.

	CE, mm mean ± SD			CCV, mm/s mean ± SD		
	Men	Women	p value	Men	Women	p value
Masseteric nerve activation	9.1 ± 3.4	7.7 ± 2.8	0.41	35.4 ± 13.8	31.3 ± 15.1	.67

Abbreviations: CE, commissure excursion; CCV, commissure contraction velocity.
No statistical differences were found.

FIGURE 2. Case of masseteric neurotization in a 46-year-old woman with complete right facial palsy secondary to acoustic neuroma resection. Three years after injury, smile reanimation was carried out with a free gracilis muscle transplant neurotized to the masseteric nerve. Preoperative appearance at rest (A) and smiling (B). (C) The recording of movement at rest after the final result at 1 year postoperatively using the FACIAL CLIMA system and (D) when smiling. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

explorations, neither spontaneity nor movement dissociation had been observed. Thus, the question arises, what makes the female brain more plastic than the male's, at least regarding smile restoration? We hypothesize that intrinsic social sex differences together with an early ability of women to re-educate the movement of smiling are part of the answer.

Numerous studies have shown that in different circumstances, women smile more than men.[25,26] Hence, it is reasonable to think that the motivational drive toward smiling is greater in the female population and therefore it is very likely that after smile reanimation, women develop brain plasticity earlier than men on the basis that smiling is more important for them. Up to now, only clinical observation supports this theory; however, further imaging studies might yield more information on the cortical area activated in these patients and the possible sex differences.

Finally, it is important to mention that determining the presence of a spontaneous and/or a dissociated smile is somewhat observer-dependent and, thus, can only be assessed qualitatively and not quantitatively. Moreover, the extent to which both of these characteristics are developed may vary among patients, although it could be present in all of them. Finally, the stimulus to obtain a spontaneous or unconscious smile can also vary among patients and, thus, a short funny video can evoke different degrees of spontaneous smile depending on the individual's sense of humor and social conditioning. These aspects constitute the main limitations of our study.

CONCLUSIONS

Based on our clinical observations, the results presented in this study, and the clinical and experimental evidence available, we suggest that female patients could develop an earlier cortical adaptation than male patients after smile reconstruction with nerves other than the facial. Although clinical as well as experimental data support such hypothesis, further functional MRI studies must be conducted in order to confirm it.

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