Involuntary Movement during Mastication in Patients with Long-Term Facial Paralysis Reanimated with a Partial Gracilis Free Neuromuscular Flap Innervated by the Masseteric Nerve

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Background: Midface reanimation in patients with chronic facial paralysis is not always possible with an ipsilateral or contralateral facial nerve innervating a free neuromuscular tissue transfer. Alternate use of nonfacial nerves is occasionally indicated but may potentially result in inadvertent motions. The goal of this study was to objectively review videos of patients who underwent one-stage reanimation with a gracilis muscle transfer innervated by the masseteric nerve for (1) inadvertent motion during eating, (2) characterization of masticatory patterns, and (3) social hindrance perceived by the patients during meals.

Methods: Between the years 2009 and 2012, 18 patients underwent midfacial reanimation with partial gracilis muscle transfer coapted to the masseter nerve for treatment of midfacial paralysis. Sixteen patients were videotaped in detail while eating. Involuntary midface movement on the reconstructed side and mastication patterns were assessed. In addition, 16 patients were surveyed as to whether involuntary motion constituted a problem in their daily lives.

Results: All 16 patients videotaped during mastication demonstrated involuntary motion on the reconstructed side while eating. Several unique masticatory patterns were noted as well. Only one of the 16 patients reported involuntary motion as a minor disturbance in daily life during meals.

Conclusions: All patients with chronic facial paralysis who plan to undergo midface reanimation with a free tissue transfer innervated by the ipsilateral masseter nerve should be told that they would universally have involuntary animation during mastication. Most patients do not consider this a major drawback in their daily lives. (*Plast. Reconstr. Surg.* 132: 110e, 2013.)

CLINICAL QUESTION/LEVEL OF EVIDENCE: Therapeutic, IV.

The goal of facial reanimation, regardless of age or etiology, is to achieve a spontaneous, emotional smile with symmetry in both repose and animation with minimal donor-site morbidity. Although no reconstructive method has achieved complete success, neuromuscular free tissue transfer has offered the best reproducible solutions and is superior to passive solutions and local muscle transfers, although

Disclosure: *The authors have no financial interest to declare in relation to the content of this article.*

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Received for publication September 26, 2012; accepted January 31, 2013.
Presented at the Annual Meeting of the American Society of Reconstructive Microsurgery, in Naples, Florida, January 9 through 15, 2013.
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DOI: 10.1097/PRS.0b013e318290f644

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the latter may have indications in select patients and have been presented with good results by some groups.[1] In the senior author's (S.R.) opinion, use of the facial nerve for innervation of the transferred muscle, whether via a cross-facial nerve graft in a two-stage procedure or via a long, vascularized nerve pedicle in a one-stage procedure to the contralateral facial nerve,[2–4] frequently produces superior results, namely by producing a spontaneous and emotional smile. Still, there are certain indications for use of other donor nerves. A detailed discussion regarding these indications is beyond the scope of this article, but suggested indications for nonfacial donor nerve are congenital or acquired bilateral facial palsies with no available facial nerve, patients who are old and often prefer a less lengthy time of recovery, patients with a guarded lifespan, and, in the opinion of the senior author, very heavy-set faces in patients with a high body mass index. One of these optional donor nerves is a branch of the nerve to the masseter, which is recognized as a reliable and reproducible form of reconstruction (Fig. 1). Originally and unexpectedly, a spontaneous smile was not anticipated when coapting to the masseteric nerve, and patients were taught to bite in order to activate their smile. Yet some reports have suggested that spontaneity may be occasionally observed in up to 85 percent of patients; however, personal conversations with several authors of such findings reveal that these numbers are likely closer to 50 percent. It is important to note that the ability to smile without clenching should not be confused with spontaneity, perhaps also explaining some of the reported discrepancies.[5] Conversely, use of nonfacial donor nerves may cause inadvertent motion, as seen with the use of the spinal accessory nerve or the hemihypoglossal nerve.[6] Using the motor nerve to the masseter for smile reconstruction may also produce unwanted activation of the transplanted muscle during mastication. This is the first article known to the authors to report the incidence of involuntary muscle activation during mastication and to attempt to characterize mastication after free muscle transfer innervated by the masseter motor nerve, based on objective videography during mastication. In addition, patients were evaluated with regard to whether any involuntary movement was considered a major drawback.

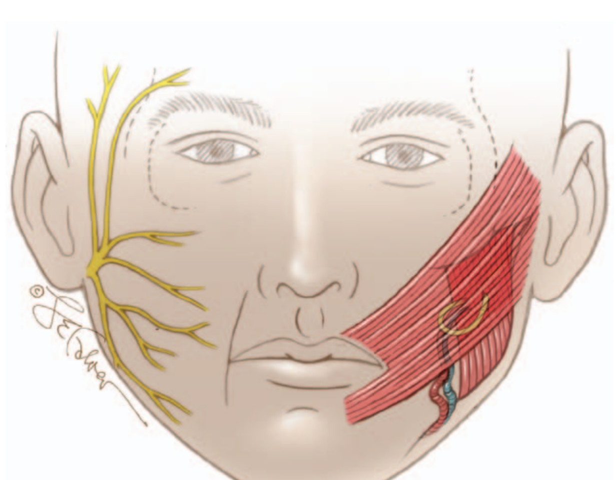


Fig. 1. Facial reanimation with a one-stage procedure using the masseter nerve.

PATIENTS AND METHODS

Eighteen patients underwent free microneurovascular transfer of the gracilis muscle to the nerve to the masseter for reconstruction of facial paralysis. Indications for use of the masseter nerve in these patients included bilateral congenital facial paralysis, old age, guarded life span, obese faces, and patient preference. All operations were performed by the senior author (S.R.) and took place between 2009 and 2012. All patients saw our physical therapist, who specializes in facial palsy, before surgery, every 3 months after surgery when possible for the first 12 months, and every 6 months in the second year. In the interval, patients saw the senior author every 3 months, to review progress and exercises. The graft failed in one patient due to an infected hematoma, and one patient died in an all-terrain vehicle accident, and although he had video follow-up, he was not available for the blinded questionnaire. After giving informed written consent, 16 patients were videotaped postoperatively while eating a crunchy granola bar. Videos were then analyzed by two teams, one with a medical background and the other without. All videos included presentation of food to the mouth, mastication on both sides (other than in one unilateral edentulous patient) with patients pointing with their finger to the side of mastication, and completion until swallowing. Each assessor individually commented on the patterns of mastication and whether he or she noticed any involuntary motion of the gracilis muscle during mastication, defined as a motion of the muscle in a vector directed from the modiolus to the cephaloauricular junction. Results were summarized based on the assessor group and compared.

In addition, a group of five patients with follow-up of longer than 20 months was assessed as to whether a longer interval from surgery and improved incorporation of the reconstruction into the smile would change the frequency of involuntary motion during mastication.

A questionnaire, which included five questions regarding the quality of mastication and satisfaction from surgery, was administered over the telephone by a clinical coordinator blinded to the patients.

This study was approved by the institutional review board of the University of Texas Southwestern Medical School.

Surgical Technique

Briefly, the technique used was a sub–superficial musculoaponeurotic system (SMAS) dissection via a preauricular incision often extended inferiorly and anteriorly posterior to the ramus, with broad exposure of the ipsilateral modiolus, lower lip, upper lip, and nasal alar base. Dissection of the anterior masseteric branch was completed. Intrafacial sub-SMAS measurements were taken from the planned insertion at the modiolus to the planned origin, mostly at the temporal fascia, including the location of planned vascular anastomoses. Number 0 Mersilene sutures (Ethicon, Somerville, N.J.) were meticulously placed in the modiolus, lower and upper lips, and sometimes at the alar base, based on preoperative assessment of nasal asymmetry. The smile pattern was verified to coincide with the expected planned vector, and care was taken to avoid inversion or eversion of the lips. Concomitantly, dissection of the gracilis muscle, while obtaining maximal vascular length and a fairly short obturator nerve, was performed. Once the above was completed, transfer of a partial gracilis muscle (35 to 50 percent of the muscle width) to the paralyzed side of the face was completed, with occasional superficial thinning of the muscle based on the surgeon's preference for the specific case. The muscle was secured distally to the modiolus, upper and lower lips, and alar base as needed and proximally to the temporal fascia in cases of paralyzed frontal branches or zygomatic arch in patients with intact frontal branches, since the dissection is sub-SMAS rather than subcutaneous (surgeons' personal preference). The above steps are finally followed by vascular anastomoses and then by neural coaptation and skin closure.

We present three case reports, including videos, with increasing time intervals (5, 22, and 40 months) from time of reconstruction.

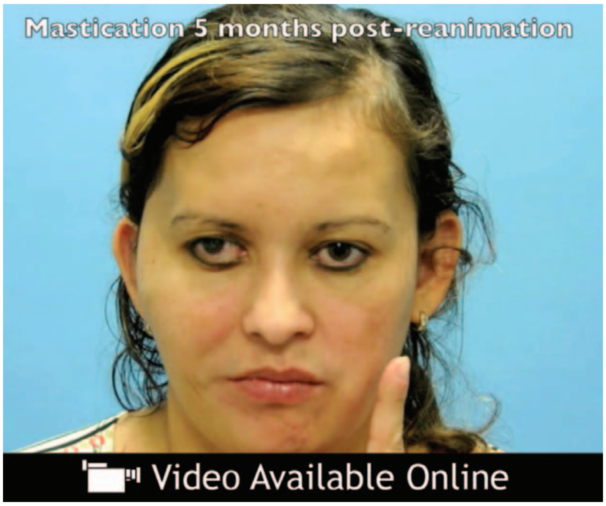
Table 1. Patient Demographics and Video Analysis Results Summary

Patient	Age at Surgery (yr)	Sex	Cause of Paralysis	Interval from Surgery to Onset of Motion (mo)	Smile without Biting	Interval from Surgery to Latest* Chewing Video (mo)	Motion with Chewing	Interval from Onset of Paralysis to Reanimation (yr)	Midface Operations Performed Elsewhere before Reanimation	Preoperative House-Brackman Score
1	13/14	M	Möbius syndrome	4 / 2	Yes	None	Yes	13/14	None	VI/VI
2	71	F	Acoustic neuroma	5	Yes	41	Yes	19	Passive sling 18 yr earlier	VI/VI
3	47	M	CN VII neuroma	3	Yes	30	Yes	2	None	VI/VI
4	60	F	Bell's palsy	5	No	24	Yes	27	Multiple passive procedures 15 yr earlier	III/VI
5†	43	M	Traumatic neuroma	3	Yes	20	Yes	20	None	VI/VI
6	45	F	Choroid plexus papilloma	2.5	Yes	22	Yes	4	None	VI/VI
7	43	M	Facial nerve schwannoma	2.5	Yes	19	Yes	12	None	VI/VI
8	61	M	Localized hypertrophic neuropathy	4	Yes	14	Yes	12	None	IV/VI
9	11	M	Traumatic neuropathy	4	No	16	Yes	7	None	III/VI
10	12	F	Ramsey Hunt syndrome	2	Yes	14	Yes	1	None	VI/VI
11	51	M	SCC with invasion of CN VII	3	No	15	Yes	2	None	VI/VI
12	41	F	Bell's palsy	4	No	13	Yes	40	None	IV/VI
13	56	F	Right recurrent temporal lobe cholesteatoma	8	No	11	Yes	6	None	VI/VI
14	67	F	Bell's palsy	3	No	9	Yes	1.5	None	III/VI
15	60	F	Bell's palsy	3	No	4	Yes	>20	None	IV/VI
16	33	F	Acoustic neuroma	3	No	5	Yes	10 months	None	VI/VI
17	64	F	Acoustic neuroma	3.5	No	4	Yes	9	None	III/VI

M, male; F, female; CN, cranial nerve; SCC, squamous cell carcinoma.

*Most patients were videotaped every 3 to 6 months, but Table 1 refers to the latest video.

†Patient died in all-terrain vehicle accident and was not available for the blinded interview.



Video 1. Supplemental Digital Content 1 shows the patient in case 1 (patient 16 in Table 1), during mastication 5 months after reanimation, ***http://links.lww.com/PRS/A744***.

Video 2. Supplemental Digital Content 2 shows the patient in case 2 (patient 7 in Table 1) during mastication 22 months after reanimation, ***http://links.lww.com/PRS/A745***.

CASE REPORTS

Case 1

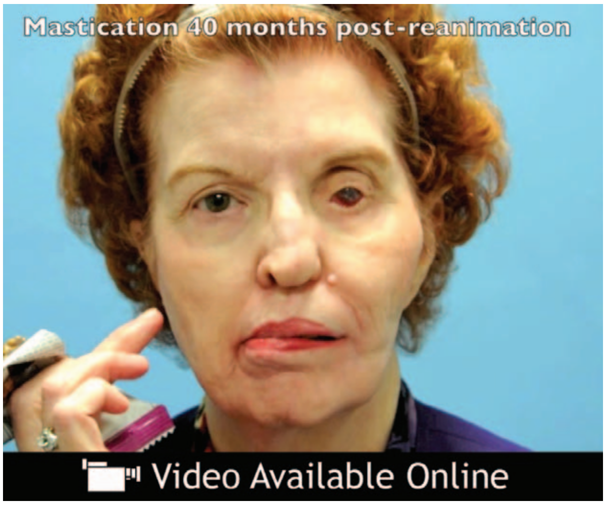
A 32-year-old woman (patient 16 in Table 1) of Hispanic descent with type 2 neurofibromatosis presented to the clinic 6 months after resection of an acoustic neuroma that necessitated sacrifice of the nerve at the brain stem level. Her chief complaints were severe facial asymmetry, dry eye and corneal irritation, difficulty breathing from the right nostril, drooling of fluids from the right oral commissure, and boluses of food stuck between the teeth and right buccal mucosa. Examination revealed a dense right-sided facial paralysis with previously inserted gold weight to the right upper eyelid. Two-stage reanimation was recommended, but she opted for one-stage reconstruction. Surgery was performed in July of 2012 using a partial gracilis muscle coapted to the masseter nerve. At 5 months postoperatively, she was starting to demonstrate good voluntary control of her smile and improved symmetry in repose and animation. She reported overall improvement during mastication. (**See Video, Supplemental Digital Content 1**, which shows the patient in case 1 (patient 16 in Table 1) during mastication 5 months after reanimation, ***http://links.lww.com/PRS/A744***.)

Case 2

A 42-year-old man (patient 7 in Table 1) presented to our skull base unit 3 years after increasing left-sided facial weakness culminating in complete, dense, left-sided facial paralysis and increased hearing loss. Chief complaints were left eye dryness and irritation, asymmetry of the face, occasional drooling of fluids from the left oral commissure, and hearing loss. Examination revealed an obese patient (body mass index 32) with a heavy-set face, dense left-sided facial paralysis, and left upper eyelid paralytic lagophthalmos. Computed tomographic and magnetic resonance imaging studies suggested schwannoma involving the vertical portion of the facial nerve in the mastoid. Nerve conduction studies revealed severely reduced amplitudes (<10 percent that of the right side), and needle electromyography showed decreased insertional activity in the frontalis, orbicularis oculi, and orbicularis oris muscles and no voluntarily recruited motor units. On February 18, 2011, a gold weight was inserted into his left upper eyelid, and on April 22, 2011, he underwent removal of a large schwannoma from the descending portion of his facial nerve on the left, followed by left midface reanimation using a free partial gracilis muscle transfer coapted to his left masseteric nerve. At his 22-month follow-up, he demonstrated good voluntary control of his smile, no spontaneity, and improvement of symmetry in repose. He reported a 90 percent improvement during mastication. (**See Video, Supplemental Digital Content 2**, which shows the patient in case 2 (patient 7 in Table 1) during mastication 22 months after reanimation, ***http://links.lww.com/PRS/A745***.)

Case 3

A 71-year-old woman (patient 2 in Table 1) was diagnosed with a left acoustic neuroma 19 years prior to presentation. At the time of diagnosis, she was treated with a gamma knife and developed left facial paralysis. She had no ocular protection at the time and lost her vision within 6 months of the gamma knife treatment.



Video 3. Supplemental Digital Content 3 shows the patient in case 3 (patient 2 in Table 1) during mastication 40 months after reanimation, ***http://links.lww.com/PRS/A746***.

Her original complaints included oral incompetence and facial asymmetry. Five months after gracilis muscle transfer, the patient noted movement while biting. At 10 months postoperatively, she was able to smile occasionally without biting but never developed spontaneity. A left-sided brow lift was performed after 16 months, and re-advancement of the flap for symmetry due to dehiscence at the insertion was performed at 26 months. While she does not smile spontaneously, she did report resolution of oral incompetence and greatly improved symmetry in repose and animation. (**See Video, Supplemental Digital Content 3**, shows the patient in case 3 (patient 2 in Table 1) during mastication 40 months after reanimation, ***http://links.lww.com/PRS/A746***.)

RESULTS

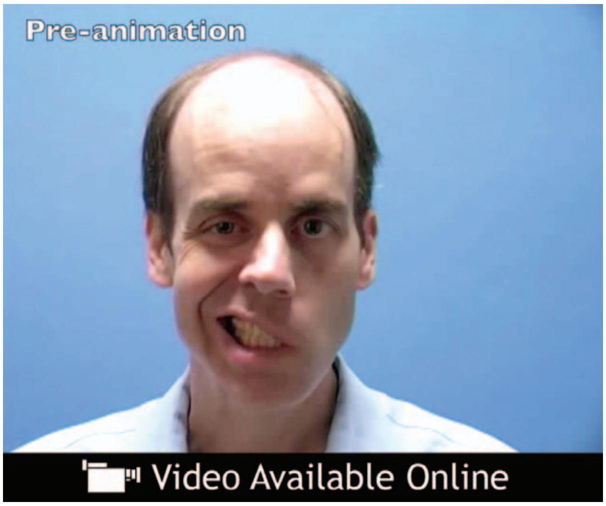
Patient age at time of surgery ranged from 11 to 71 years. Mean patient age was 45.6 years. The average time after surgery at which either the patient or the senior author noticed motion was 3.5 months. Eight patients were able to smile without biting. There were seven male and 10 female patients. For full details, see Table 1.

Mastication Video Analysis

Timing of video follow-up at the time of writing ranged from 4 to 41 months, with a mean follow-up of 16.5 months. Six distinct observations were noted while viewing detailed videography of these patients while eating (**see Videos, Supplement Digital Content 1,** demonstrating the patient in case 1 during mastication before and after reanimation, ***http://links.lww.com/PRS/A744***; and **Supplement Digital Content 2 and 3,** demonstrating involuntary motion in the patients in cases 2 and 3, respectively, during eating and several mastication characteristics, ***http://links.lww.com/PRS/A745*** and ***http://links.lww.com/PRS/A746***):

1. All patients revealed involuntary motion while chewing both on the normal side and on the reconstructed side.
2. All patients introduce food into the mouth via the nonreconstructed side.
3. All patients prefer chewing on the nonreconstructed side.
4. Chewing on the nonreconstructed side may decrease involuntary motion in some patients, but this finding is inconsistent.
5. Some patients occasionally either chew with lateral motion, likely increasing use of the pterygoids, or incorporate smaller bites with less force to decrease involuntary motion.

Regardless of age, time interval from surgery, or ability to smile without occlusion, patients continued demonstrating involuntary motion during mastication. (**See Video, Supplemental Digital Content 4**, which shows smiling without clenching and mastication at 30 months, ***http://links.lww.com/PRS/A747***.)



Video 4. Supplemental Digital Content 4 shows smiling without clenching and mastication at 30 months after reanimation (patient 3 in Table 1), ***http://links.lww.com/PRS/A747***.

When comparing video analysis between medical personnel and nonmedical personnel, although both groups noticed involuntary motion in all the cases, the blinded nonmedical evaluators noted significant involuntary motion in only 60 percent of the videos as opposed to the authors' rating of 100 percent.

Blinded Questionnaire Analysis

The average follow-up from day of surgery to time of blinded questionnaire was 18.5 months (Table 2). Of the 16 patients who were asked whether this involuntary motion disturbed them while eating, only one stated that it was minimally bothersome; the remaining 15 patients did not complain, even when specifically asked. Ninety

Table 2. Blinded Questionnaire of 16* Patients Reanimated with the Masseteric Nerve, with Average Follow-Up of 18.5 Months

Question	Response Rate
Have you noticed abnormal motion while eating?	33%
Does this motion bother you during mastication?	10%
Have you noted changes while eating over time?	90% described improvement
Do you have problems eating with company?	40%
Do you have problems eating alone?	40%
Would you have the surgery again?	100%

*Of the 18 patients, one patient had a video but died before the blinded questionnaire was administered; treatment of one patient failed due to an infected hematoma.

percent reported overall improvement in their mastication, but 40 percent continued to have problems during mastication. These problems were not related to the involuntary motion but rather to problems they experienced before reconstruction, mainly food accumulation between the teeth and buccal mucosa. All patients stated they would repeat the surgery without hesitation.

DISCUSSION

Use of nonfacial nerves for facial reanimation is usually not the first choice, and as opposed to the facial nerve, nonfacial nerves will usually not provide a spontaneous smile and will likely cause involuntary, unsolicited motions. For example, use of the accessory nerve may create an unwanted smile while shrugging the shoulders, use of the hemihypoglossal nerve may cause inadvertent motion when speaking or more often when eating, and use of the masseteric nerve may produce uncontrolled smiling when eating. Our nerve of choice, when we are not using a cross-facial nerve, is the masseter motor nerve, which allows for a one-stage reconstruction in select patients. Patients in whom we more commonly use this technique are those with no ipsilateral or contralateral facial nerve, older patients, patients with a guarded lifespan, obese patients with heavy faces, and those who prefer one-stage reconstruction. The advantages are minimal donor-site morbidity, presence of the nerve within the facial operative field, and sufficient muscle excursion often greater than that attributed to a cross-facial nerve graft.[7] Several authors even report spontaneous smiling over time in some patients, although the reported prevalence of spontaneity varies and definitions of spontaneity likely vary as well.[8]

The anatomic location of the masseter motor nerve has been well described.[9] Its branching pattern has also been identified,[10] with two or more branches to the nerve in 75 percent of cases. In our patients, we have found that severe dysfunction of the masseter muscle did not result as a consequence of using this nerve in facial reanimation. On the other hand, this branching pattern may also instigate simultaneous activation of both the masseter and the free muscle transfer, resulting in smile-like movements during chewing. Manktelow et al.[5] reported subjective improvement in eating and drinking in patients who underwent reconstruction, but details regarding involuntary motion during mastication were not provided.

We hypothesized that while patients do not complain of inadvertent movement of their free muscle transfer when chewing, it does occur in most patients. We also wanted to assess postoperative chewing patterns and whether muscle activation while eating bothered the patients and interfered with meals. As a secondary goal, despite the known limitation of a small group of patients, we inquired whether factors such as time interval from surgery, age, and successful incorporation of the reconstruction, as evidenced by the ability to smile without occlusion, would decrease involuntary motion during mastication.

By reviewing postreconstruction videos of 16 patients who demonstrated an ability to smile, with a broad spectrum of ages and causes of facial paralysis, several interesting findings were observed and are detailed in the Results section, demonstrating a few important points. (1) All patients revealed involuntary motion while chewing both on the normal side and on the reconstructed side. (2) Some patients adopted certain eating patterns that occasionally decreased involuntary motion, but these constituted more of a behavioral modification rather than cortical adaptation. (3) Regardless of age, time interval from surgery, and the ability to incorporate the reconstruction into a smile effectively, as evidenced by a coordinated smile and the ability to smile without occlusion, all patients continued to demonstrate involuntary motion during mastication. This notion was strengthened in our analysis of a subset of five patients with follow-up longer than 20 months and good incorporation of their reconstruction. In these patients, we did not observe any clear trend in decrease or increase in involuntary motion during mastication (**see Video, Supplemental Digital Content 4, *http://links.lww.com/PRS/A747***).

Of the 16 patients interviewed, only one was mildly bothered by the involuntary motion during mastication; the other 15 patients were not concerned. All patients were very happy with the results and would repeat the surgery. The persistent problems during mastication reported by 40 percent of patients were not associated with involuntary motion but rather with pre-existing problems from the paralysis, and 90 percent actually reported overall improvement during eating.

Several additional findings were noted. Most patients developed motion within 3 to 6 months after surgery, except for one patient, who started animating at 8 months. Also, 50 percent of our patients were able to smile without biting. This was demonstrated by the patients when specifically asked to smile with an open mouth without clenching the teeth, but it was not evaluated in a regular conversational environment. This is less than the 85 percent reported by Manktelow et al.,[5] but this discrepancy might also be explained by of our shorter follow-up.

Nonetheless, informed consent requires protection of patient autonomy through the provision of potential benefits and risks of treatment. As alterations in facial motion during eating may be as socially unsettling as asymmetries in smile, it is the surgeon's responsibility to include this in the discussion with the patient and in the informed consent. From these results, it may be concluded that patients undergoing a free muscle transfer of the gracilis muscle will invariably develop involuntary motion during mastication, but to most patients, this is of minimal hindrance or concern. Lengthier follow-up will also be necessary to determine whether this unwanted motion seen during mastication is modified through the cerebral adaptation, as demonstrated in some patients capable of generating a spontaneous smile according to some reports. However, on the basis of our results in the cases with longer-term follow-up, we did not note any decrease in frequency or strength of involuntary motion. Most changes over time that may decrease involuntary motion seem behavioral rather than cortical adaptation. Still, it may be possible that as the cortex adapts to the use of the masseteric nerve as a nerve of facial expression,[11] its function during mastication will decrease, resulting in lessened muscle motion.

CONCLUSIONS

On the basis of our series and current follow-up, all facial paralysis patients reconstructed with free muscle transfer innervated by the masseteric nerve will universally demonstrate involuntary motion during mastication, and this should be noted in the informed consent process. Yet, most patients considered this as no to minimal hindrance, and all would repeat the procedure. Some patients may adapt new chewing patterns to possibly decrease inadvertent motion, and perhaps these might be suggested in their postoperative therapy and rehabilitation.

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PATIENT CONSENT

Patients provided written consent for the use of their images.

ACKNOWLEDGMENTS

The authors thank Lisa Belser, their talented photographer at University of Texas Southwestern Medical Center, for the videos made for this article; Lewis Calver, medical illustrator, for his wonderful graphics; and Toni Salvadore, their clinical coordinator.

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