

Original Investigation

Development and Validation of a Spontaneous Smile Assay

Carlo M. Iacolucci, MD; Caroline Banks, MD; Nate Jowett, MD; Elliott D. Kozin, MD; Prabhat K. Bhamra, MD, MPH; Maurizio Barbara, MD, PhD; Tessa A. Hadlock, MD

IMPORTANCE Smiling can be a voluntary or involuntary movement. Facial reanimation procedures differ in their ability to restore a spontaneous smile, and an assay designed to evoke and evaluate a spontaneous smile is not available.

OBJECTIVE To develop and validate an assay to assess the spontaneous smile of patients with facial paralysis.

DESIGN, SETTING, AND PARTICIPANTS This was an exploratory cohort study. A series of short video clips were administered to laypersons via an online survey service from January 1, 2014, to March 31, 2014. Respondents rated how funny each video was on a visual analog scale from 0 to 100. The 4 funniest videos were selected to generate a 1½-minute spontaneous smile assay. The assay was then administered from July 1, 2014, to December 31, 2014, to 2 different study groups: the first was composed of 100 healthy individuals (control group) and the second was composed of 30 patients with facial paralysis. We analyzed the capability of this assay to provoke at least 1 spontaneous smile and calculated smile excursion in both groups. Statistical analysis was performed using analysis of variance.

INTERVENTION Spontaneous smile assay administered to both healthy and diseased groups.

MAIN OUTCOMES AND MEASURES Ability of the assay to elicit smiles, as defined by an oral commissure excursion greater than 3 mm, as well as difference in commissure excursion.

RESULTS Ninety-five (95.0%) participants in the control group and 29 (96.7%) patients with facial paralysis experienced at least 1 oral commissure excursion that appeared to be a spontaneous smile while viewing the assay. Mean oral commissure excursion with spontaneous smile was 9.08 mm (95% CI, 2.77-15.39) in controls, 6.72 mm (95% CI, 3.13-10.31) on the healthy side in patients with flaccid facial paralysis ($P=.004$ vs controls), and 9.64 mm (95% CI, 3.52-15.76) on the healthy side in patients with nonflaccid facial paralysis ($P=.74$). Among patients with flaccid facial paralysis, a statistically significant difference was found between smile excursion of the affected and the unaffected sides ($P = .03$). There was no statistically significant difference in the measurement between sides for the control group ($P = .67$).

CONCLUSIONS AND RELEVANCE Although humor is a challenging construct to universalize, our assay was able to elicit a smile in almost all individuals in the group with facial paralysis and the control group. The spontaneous smile assay will facilitate future research on the ability of facial reanimation procedures and other interventions to restore a spontaneous smile.

LEVEL OF EVIDENCE NA.

JAMA Facial Plast Surg. 2015;17(3):191-196. doi:10.1001/jamafacial.2015.0083
Published online March 26, 2015.

Author Affiliations: Division of Facial Plastic and Reconstructive Surgery, Department of Otolaryngology, Harvard Medical School, Massachusetts Eye and Ear Infirmary, Boston (Iacolucci, Banks, Jowett, Kozin, Hadlock); Department of Neuroscience, Mental Health and Sense Organs, La Sapienza University, Sant'Andrea Hospital, Rome, Italy (Iacolucci, Barbara); Department of Otolaryngology-Head and Neck Surgery, Alaska Native Tribal Health Consortium, Anchorage (Bhamra).

Corresponding Author: Caroline Banks, MD, Division of Facial Plastic and Reconstructive Surgery, Department of Otolaryngology, Harvard Medical School, Massachusetts Eye and Ear Infirmary, Boston, MA 02114 (caroline_banks@meei.harvard.edu).

The smile is a universal expression across all cultures and is essential in verbal and nonverbal communication.^{1,2} An individual produces a volitional smile (eg, during a photograph) via the corticobulbar pathways originating in the precentral and postcentral gyri. These pathways traverse the internal capsule and subsequent synapses in the facial nerve nucleus located in the pons. A spontaneous or involuntary smile is the result of neural input to the facial nuclei originating from the thalamus and globus pallidus in response to something pleasant or funny. Differences between spontaneous and volitional smiles are also evident on the macroscopic level. The genuine expression of positive emotion results in a Duchenne smile, which involves contraction of the zygomaticus major muscles and the orbicularis oculi muscles.³ The social smile, also referred to as the volitional or non-Duchenne smile, differs from the Duchenne smile in that it lacks orbicularis oculi contraction.⁴ While most smile reanimation procedures do not restore authentic activation of orbicularis oculi muscles, certain surgical approaches enable the patient to smile spontaneously, while results of other reanimation procedures require the patient to voluntarily smile. For the purposes of this study, we define *spontaneous smile* as involuntary smile movement that occurs with authentic positive emotion.

Beginning in early childhood, humans use volitional and spontaneous smiles to convey emotions such as joy and happiness as well as to build and maintain social relationships.⁵ The inability to smile has dramatic aesthetic, functional, and psychosocial implications, leading to decreased quality of life.⁶ Because of this negative effect on quality of life, much effort in the field of facial reanimation has focused on restoring a spontaneous smile. Although facial reanimation procedures aimed at dynamic smile reanimation result in measurable oral commissure excursion⁷ and improved quality of life,⁸ substantial room for improvement exists in reporting outcomes.

Contemporary smile outcomes rely on the patient's ability to produce a voluntary smile. While some authors describe assessment of postoperative spontaneous smiling,⁹⁻¹¹ most postintervention measurements fail to ascertain whether patients are able to produce a spontaneous smile and thus do not capture important information regarding genuine smile function. Moreover, it is possible that patients achieve maximal oral commissure excursion only with a spontaneous smile. To facilitate future research on the ability of facial reanimation procedures and other interventions to restore a spontaneous smile, the Facial Nerve Center at the Massachusetts Eye and Ear Infirmary (MEEI) has developed a spontaneous smile assay (SSA) designed to stimulate a spontaneous smile in patients with facial paralysis. We describe the development and administration of the SSA in both healthy individuals and patients with facial paralysis.

Methods

Video Development

Searches of YouTube and Google were used to identify comedic video clips by using the search terms *funny videos*,

funny, and *funniest videos*. Two hundred videos lasting less than 15 minutes were selected and viewed by one of us (P.K.B.). Videos were excluded if the comedic event occurred more than 15 seconds after the beginning of the video, if the video required understanding of English, or if the video contained inappropriate content. Twenty-five videos were included in the secondary analysis and viewed by a group of 5 physicians, physician assistants, and physiotherapists specializing in facial nerve disorders. The funniest 10 videos were chosen for inclusion in the study. Using iMovie for Mac (Apple Inc), each video was trimmed to less than 22 seconds. An online survey (Survey Gizmo) was compiled and distributed electronically to colleagues and friends in the United States, England, Canada, Brazil, and Europe, from January 1, 2014, to March 31, 2014. The survey asked the respondent to report how funny each of the 10 videos was on a visual analog scale from 0 to 100 (termed *funniness rating* [FR]). We were able to identify 4 videos that were rated highly by most respondents to create an SSA to measure a spontaneous smile in patients with facial paralysis.

Prospective Analysis and Data Collection

Institutional review board approval was obtained by the MEEI Human Study Committee and written informed consent was obtained for all participants. We administered the SSA to a group of 100 healthy individuals (control group) and to a group of 30 patients with facial paralysis, from July 1, 2014, to December 31, 2014. The SSA was displayed on an iPad (Apple Inc) and a Sony Digital video camera (Sony Corporation) was used to videotape participants while they were watching the SSA. Both the iPad and video camera were fixed on a tripod. Participants were asked to watch the video while sitting on a chair at a distance of 100 cm from the tripod. To facilitate facial measurements and evaluation, a headrest was used to reduce head movements, and the midline position of the participant's face was aligned with a pointer (Figure 1).

Control Group

Controls were recruited within the MEEI community (eg, employees, visitors, colleagues, students, and patients' relatives). Individuals with a history of neurologic and/or neuromuscular disease (eg, facial paralysis) were excluded from the study. After providing informed consent, participants were seated and positioned into the headrest apparatus. Each participant viewed the SSA twice, with an interval of 20 seconds between the 2 trials. Participants were instructed to act naturally and not to force a smile. They were specifically instructed that there was no expectation of smile performance, and were left in private for viewing the video. Videos were viewed on a computer by one of us (C.M.I.) using VLC software (VideoLAN), and 3 still photographs were obtained for each participant: one at rest, one capturing the biggest smile during the first trial, and one of the biggest smiles during the second trial. Comparisons of still photographs taken at rest and taken during the biggest smile were performed using ImageJ (<http://imagej.nih.gov/ij>), which is an automated tool designed to measure the distances between land-

marks. Using the mark positioned at the midline, a line is traced from the midline vermilioncutaneous border of the lower lip to the oral commissure on both sides at rest (rest position) and at the moment of the biggest smile (smile position). The change in the distance between rest and smile positions is referred to as *smile excursion*.

Facial Paralysis Group

Thirty consecutive patients with facial paralysis were recruited from the Facial Nerve Center at MEEI. The facial paralysis group included patients affected by paralysis of several etiologies and different degrees. We were able to identify 2 subgroups: the flaccid facial paralysis (FFP) group (patients with no volitional movement in any division of the facial nerve on the affected side) and the nonflaccid facial paralysis group (patients with synkinesis, hypertonicity, and poor voluntary and/or involuntary motor control after facial nerve insult and recovery).⁹ The SSA was administered to the facial paralysis groups in a similar fashion to that of the control group, except that the video was shown only once. Video analysis was carried out with ImageJ as described for the control group, and measures of rest position, smile position, and smile excursion were obtained for the healthy and paralyzed sides of the face.

Statistical Analysis

Normality of the data for all groups was confirmed using Q-Q plots and Shapiro-Wilk tests. Using the control group, the population mean (SD) and 95% CIs of a smile excursion with spontaneous smile were estimated. Measures between trials and between sides of the face were compared using 2-tailed independent samples *t* tests. Assay validity was assessed using Pearson intraclass correlation coefficient as a measure of test-retest reliability. Next, power analysis determined that at least 17 patients with hemi-facial paralysis would be required to detect a greater than 25% difference in smile excursion from healthy controls with a power of at least 80%. Subgroup analysis using 2-tailed 1-way analysis of variance with Games-Howell post hoc testing was then performed to compare smile excursion between healthy controls and patients with either FFP or nonflaccid facial paralysis. Finally, a 1-tailed paired-samples *t* test was used to compare the commissure position on the paralyzed side in patients with FFP during rest and smile to determine whether spontaneous smile-induced contraction of the contralateral face would tension the paralyzed commissure toward the midline. For all tests, α was set at .05. Statistical analysis was performed using IBM SPSS Statistics, version 22 (IBM Corp).

Results

SSA Development

The number of total respondents to the online survey was 266, with 234 (88.0%) from the United States, 8 (3.0%) from England, 5 (1.9%) from Canada, 15 (5.6%) from Europe (not including England), and 4 (1.5%) from Brazil. The 4 videos with the highest FR (“Small dog dancing,” “Baby lemon 1,”

Figure 1. Headrest Apparatus Designed to Reduce Head Movements



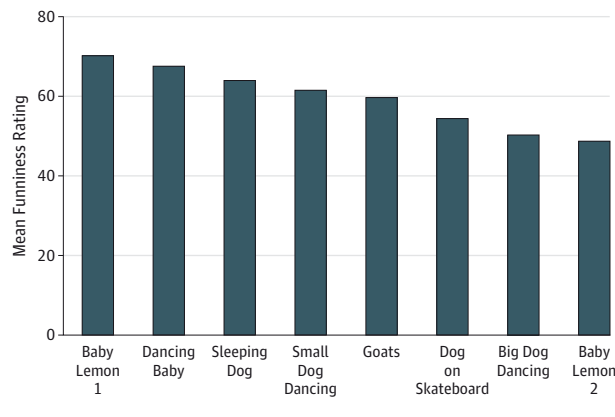
The midline position of the participant's face is aligned with a pointer (arrowhead).

“Sleeping dog,” and “Dancing baby”) were used to create a 1½-minute SSA. Laugh tracks (audio clips of laughter at relevant time points) were added to increase the probability of eliciting a spontaneous smile, based on the well-known effectiveness of laugh tracks to enhance laughter and the perceived funniness of comedic material.¹² The “Baby lemon 1” video was rated the funniest overall video (FR, 70.18). The second funniest (FR, 67.56) video was the “Dancing baby” video. The difference between the FR of these 2 videos did not reach statistical significance ($P = .16$, 2-tailed *t* test). The mean FR of the 8 funniest videos is reported in Figure 2.

Control Group

One hundred participants ranging from 12 to 81 years old (mean [SD] age, 40.3 [16.8]; 41 males and 59 females) were recruited. A total of 200 videos were recorded (2 for each participant). Ninety-five participants (95.0%) experienced at least 1 oral commissure movement that appeared to reflect a spontaneous smile during the first trial. Ninety-one of the 95 participants (95.8%) who smiled during the first trial produced a smile at least 1 time during the second viewing of the video. A total of 372 hemi-smiles were analyzed. Mean smile excursion with

Figure 2. Mean Funniness Ratings for Top 8 Videos



The 4 videos with the highest rating were used to create the spontaneous smile assay.

Table 1. Smile Excursion With Spontaneous Smile on Healthy Side of Face for Patients With Facial Paralysis

Type of Paralysis	No.	Mean (SD), mm	P Value ^a
Flaccid facial paralysis	11	6.72 (1.83)	.004 ^b
Nonflaccid facial paralysis	18 ^c	9.64 (3.12)	.74

^a One-way analysis of variance (2-tailed) with Games-Howell post hoc testing, vs healthy controls.

^b Significant at $\alpha = .05$.

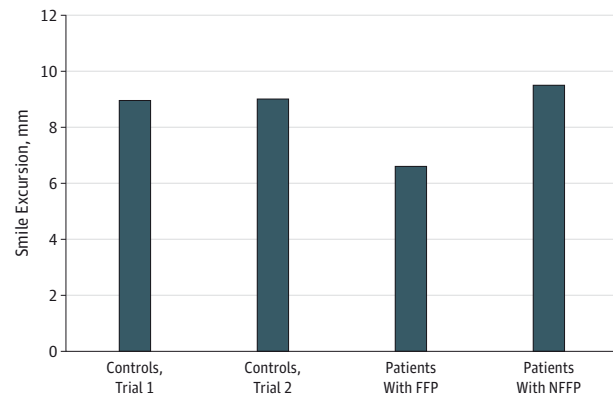
^c Eighteen of 19 patients with nonflaccid facial paralysis produced a spontaneous smile excursion with the assay.

spontaneous smile in controls was 9.08 mm (95% CI, 2.77-15.39). There was no statistically significant difference in the measurement between sides for healthy controls ($P = .67$). There was no statistically significant difference in the measures between trials (trial 1: mean [SD] smile excursion, 9.07 [3.23] mm; trial 2: mean [SD] smile excursion, 9.07 [3.22] mm; $P = .75$).

Facial Paralysis Group

Thirty videos were recorded for 30 patients with facial paralysis (age range, 15-78 years; mean [SD] age, 49.2 [17.6] years; 14 males and 16 females). The most common cause of facial paralysis was Bell palsy (53%), followed by vestibular schwannoma (10%), brain tumor (10%), Lyme disease (7%), and other causes (20%). Eleven patients (37%) had FFP and 19 patients (63%) had nonflaccid facial paralysis. Twenty-nine patients (96.7%) produced at least 1 oral commissure movement that appeared to reflect a spontaneous smile. A total of 58 hemi-smiles were analyzed. Mean oral commissure excursion with spontaneous smile was 6.72 mm (95% CI, 3.13-10.31) on the healthy side in patients with flaccid facial paralysis ($P = .004$ vs controls) and 9.64 mm (95% CI, 3.52-15.76) on the healthy side in patients with nonflaccid facial paralysis ($P = .74$). Subgroup analysis with post hoc testing revealed a significant reduction in smile excursion with spontaneous smile on the healthy side of the face in patients with FFP compared with

Figure 3. Smile Excursion on the Healthy Side of the Face for Controls and Patients With Facial Paralysis



Mean smile excursion on the healthy side of patients with flaccid facial paralysis (FFP) was significantly decreased compared with the healthy side of patients with nonflaccid facial paralysis (NFFP) and controls.

that in healthy controls (Table 1 and Figure 3). In addition, there was a significant deviation of the oral commissure on the affected side of 1.56 mm toward the midline triggered by smiling in patients with FFP (Table 2).

Discussion

Smiling is fundamental for human communication,⁵ and the loss or impairment of the ability to smile has a dramatic effect on quality of life.⁶ Free gracilis muscle transfer is the criterion standard for dynamic smile rehabilitation in patients who lack re-innervatable muscle⁷ and has been shown to significantly improve quality of life in patients with FFP and nonflaccid facial paralysis.⁸ Free gracilis muscle transfer may be accomplished in a 1-stage procedure using the masseteric branch of the trigeminal nerve to power the gracilis muscle or in a 2-stage procedure driven by a cross-face nerve graft. Free gracilis muscle transfer has the potential to restore a spontaneous smile when the muscle is innervated with a cross-face nerve graft; however, some authors report the development of spontaneous smile after 1-stage free gracilis muscle transfer.^{10,11,13} A potential explanation cited for the development of spontaneous smile after masseteric innervation is the reactivation of latent central connection between the smile and the chewing center.^{10,11,13,14} Another option for dynamic smile reanimation is a nerve transfer, or the coaptation of an alternative motor nerve source to the affected facial nerve. This procedure is performed in situations where the distal facial nerve is intact and the facial musculature is viable. As with 2-stage free gracilis muscle transfer, nerve transfer powered by the healthy facial nerve has the potential to restore a spontaneous smile. More frequently used nerve transfers, including those of hypoglossal and masseteric nerves, commonly result in a volitional smile, although some series

Table 2. Commissure Distance From Midline on Diseased Side of Face in Patients With Flaccid Facial Paralysis

Facial Expression	Mean (SD), mm	Difference ^a	P Value ^b
Rest	25.29 (3.05)	-1.56 (-2.92 to -0.20)	.03 ^c
Smile	23.73 (3.89)		

^a 1-Tailed 95% CI.^b 1-Tailed t test.^c Significant at $\alpha = .05$.

describe the development of spontaneous smile after these procedures.^{10,11,13}

Evaluation of a spontaneous smile in most facial nerve centers relies on questionnaires compiled by patients or direct observation of the patient's face. To definitively establish whether a 1-stage free gracilis muscle transfer and nerve transfers have the potential to produce a spontaneous smile, an outcome measure aimed at producing a spontaneous smile is essential.

Although humor varies widely across cultures and among individuals,⁵ the SSA elicited at least 1 smile in 95.0% of participants in the control group. We did not make specific measurements of orbicularis oculi contraction on the healthy side in patients with facial paralysis, but we assumed spontaneity of a smile based on our initial reports that the majority of respondents to our survey found the videos selected for the assay to be funny. Our objective was to prospectively evaluate the SSA on a heterogeneous group of individuals, with differing ethnicities, ages, and socioeconomic backgrounds. Massachusetts Eye and Ear Infirmary is a tertiary care center in a large city with many international visitors, patients, and staff, which allows for the recruitment of a heterogeneous group of participants.

Once the SSA is implemented into clinical care, patients would be required to view the SSA multiple times during their treatment to evaluate interventions and document the change of response to the examination across time. To ensure that the SSA is able to elicit a smile after multiple viewings, we presented the SSA to the control group twice in a short period. Even with the short duration of 20 seconds between trials, 95.8% of the participants who smiled during the first viewing produced a spontaneous smile during the second viewing. Individuals who did not smile during the first video (5.0%) did not smile during the second viewing. The mean smile excursion value in the control group was similar to that reported previously in a healthy population,¹⁵ with similar values on the left and right sides of the face and similar values in the first and second trials. The strong statistical correlation found between smile excursion values between trials confirms the effectiveness of the SSA to consistently elicit a spontaneous smile.

The SSA was also effective in eliciting a spontaneous smile from 96.7% of the patients with facial paralysis. The SSA was administered at the end of the initial visit, when patients may be more at ease and able to react to something pleasant or funny. There was no statistically significant difference in the mean smile excursion value between controls and smiles on the healthy side of the face in patients with nonflaccid facial paralysis. Interestingly, the smile excursion value on the healthy side of the face in patients with FFP was significantly decreased when compared with the smile excursion value of healthy controls. These findings could be explained as an involuntary attempt to balance facial expression in those affected by complete, unilateral facial paralysis. The facial paralysis group included patients with facial paralysis from varying etiologies and durations. While there was concern that patients with more severe or life-threatening causes of facial paralysis (eg, malignant tumor) would be less likely to produce a spontaneous smile during the SSA than patients with more benign prognoses (eg, viral-associated facial paralysis), we did not find differences with respect to etiology. The SSA was able to provoke a spontaneous smile in nearly all patients, independent of etiology and duration of paralysis.

During the physical examination, assessment of a smile is typically dependent on volitional movement by the patient. However, assessment of a spontaneous smile plays an important role in the evaluation of the patient with facial paralysis. For this reason, we sought to develop an SSA for use in patients regardless of age, sex, or cultural background.

Conclusions

Although humor is a challenging construct to universalize, our SSA was able to elicit a spontaneous smile in almost all participants, both in patients with facial paralysis and healthy controls. The SSA will facilitate future research on the ability of facial reanimation procedures and other interventions to restore a spontaneous smile.

ARTICLE INFORMATION

Accepted for Publication: January 20, 2015.

Published Online: March 26, 2015.
doi:10.1001/jamafacial.2015.0083.

Author Contributions: Dr Iacolucci had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Iacolucci, Kozin, Bhama, Barbara, Hadlock.

Acquisition, analysis, or interpretation of data: Iacolucci, Banks, Jowett, Kozin, Bhama, Hadlock.

Drafting of the manuscript: Iacolucci, Banks, Jowett, Kozin, Barbara, Hadlock.

Critical revision of the manuscript for important intellectual content: Iacolucci, Banks, Jowett, Kozin, Bhama, Hadlock.

Statistical analysis: Jowett, Bhama.

Administrative, technical, or material support: Iacolucci, Kozin, Hadlock.

Study supervision: Iacolucci, Banks, Kozin, Hadlock.

Conflict of Interest Disclosures: None reported.

REFERENCES

- Ekman P, Friesen WV, O'Sullivan M, et al. Universals and cultural differences in the judgments of facial expressions of emotion. *J Pers Soc Psychol.* 1987;53(4):712-717.
- Ekman P, Friesen WV. *Unmasking the Face: A Guide to Recognizing Emotions From Facial Clues.* Englewood Cliffs, NJ: Prentice-Hall; 1975.
- Duchenne de Boulogne GB, Cuthbertson RA. *The Mechanism of Human Facial Expression.* Cambridge, UK: Cambridge University Press; 1990.

4. Krumhuber EG, Manstead AS. Can Duchenne smiles be feigned? new evidence on felt and false smiles. *Emotion*. 2009;9(6):807-820.
5. Niedenthal PM, Mermillod M, Maringer M, Hess U. The Simulation of Smiles (SIMS) model: embodied simulation and the meaning of facial expression. *Behav Brain Sci*. 2010;33(6):417-433.
6. Coulson SE, O'Dwyer NJ, Adams RD, Croxson GR. Expression of emotion and quality of life after facial nerve paralysis. *Otol Neurotol*. 2004;25(6):1014-1019.
7. Bhama PK, Weinberg JS, Lindsay RW, Hohman MH, Cheney ML, Hadlock TA. Objective outcomes analysis following microvascular gracilis transfer for facial reanimation: a review of 10 years' experience. *JAMA Facial Plast Surg*. 2014;16(2):85-92.
8. Lindsay RW, Bhama P, Hadlock TA. Quality-of-life improvement after free gracilis muscle transfer for smile restoration in patients with facial paralysis. *JAMA Facial Plast Surg*. 2014;16(6):419-424.
9. Lindsay RW, Bhama P, Weinberg J, Hadlock TA. The success of free gracilis muscle transfer to restore smile in patients with nonflaccid facial paralysis. *Ann Plast Surg*. 2014;73(2):177-182.
10. 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(4):885-899.
11. 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(8):1176-1180.
12. Chapman AJ. Funniness of jokes, canned laughter and recall performance. *Sociometry*. 1973;36(4):569-578. doi:10.2307/2786252.
13. Wang W, Yang C, Li W, Li Q, Zhang Y. Masseter-to-facial nerve transfer: is it possible to rehabilitate the function of both the paralyzed eyelid and the oral commissure? *Aesthetic Plast Surg*. 2012;36(6):1353-1360.
14. 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(6):1472-1479.
15. Hadlock TA, Urban LS. Toward a universal, automated facial measurement tool in facial reanimation. *Arch Facial Plast Surg*. 2012;14(4):277-282.