Original Investigation

Quality-of-Life Improvement After Free Gracilis Muscle Transfer for Smile Restoration in Patients With Facial Paralysis

Robin W. Lindsay, MD; Prabhat Bhama, MD; Tessa A. Hadlock, MD

IMPORTANCE Facial paralysis can contribute to disfigurement, psychological difficulties, and an inability to convey emotion via facial expression. In patients unable to perform a meaningful smile, free gracilis muscle transfer (FGMT) can often restore smile function. However, little is known about the impact on disease-specific quality of life.

OBJECTIVE To determine quantitatively whether FGMT improves quality of life in patients with facial paralysis.

DESIGN, SETTING, AND PARTICIPANTS Prospective evaluation of 154 FGMTs performed at a facial nerve center on 148 patients with facial paralysis. The Facial Clinimetric Evaluation (FaCE) survey and Facial Assessment by Computer Evaluation software (FACE-gram) were used to quantify quality-of-life improvement, oral commissure excursion, and symmetry with smile.

INTERVENTION Free gracilis muscle transfer.

MAIN OUTCOMES AND MEASURES Change in FaCE score, oral commissure excursion, and symmetry with smile.

RESULTS There were 127 successful FGMTs on 124 patients and 14 failed procedures on 13 patients. Mean (SD) FaCE score increased significantly after successful FGMT (42.30 [15.9] vs 58.5 [17.60]; paired 2-tailed *t* test, $P < .001$). Mean (SD) FACE scores improved significantly in all subgroups (nonflaccid cohort, 37.8 [19.9] vs 52.9 [19.3]; $P = .02$; flaccid cohort, 43.1 [15.1] vs 59.6 [17.2]; $P < .001$; trigeminal innervation cohort, 38.9 [14.6] vs 55.2 [18.2]; $P < .001$; cross-face nerve graft cohort, 47.3 [16.6] vs 61.7 [16.9]; $P < .001$) except the failure cohort (36.5 [20.8] vs 33.5 [17.9]; Wilcoxon signed-rank test, $P = .15$). Analysis of 40 patients' photographs revealed a mean (SD) preoperative and postoperative excursion on the affected side of −0.88 (3.79) and 7.68 (3.38), respectively ($P < .001$); symmetry with smile improved from a mean (SD) of 13.8 (7.46) to 4.88 (3.47) ($P < .001$).

CONCLUSIONS AND RELEVANCE Free gracilis muscle transfer has become a mainstay in the management armamentarium for patients with severe reduction in oral commissure movement after facial nerve insult and recovery. We found a quantitative improvement in quality of life after FGMT in patients who could not recover a meaningful smile after facial nerve insult. Quality-of-life improvement was not statistically different between donor nerve groups or facial paralysis types.

LEVEL OF EVIDENCE 3.

JAMA Facial Plast Surg. 2014;16(6):419-424. doi:10.1001/jamafacial.2014.679
Published online October 2, 2014.

Author Affiliations: Department of Otolaryngology/Head and Neck Surgery, Massachusetts Eye and Ear Infirmary and Harvard Medical School, Boston.

Corresponding Author: Robin W. Lindsay, MD, Division of Facial Plastic and Reconstructive Surgery, Massachusetts Eye and Ear Infirmary, 243 Charles St, Boston, MA 02114 (robin_lindsay@meei.harvard.edu).

Development of facial paralysis can contribute to facial disfigurement, psychological difficulties, and an inability to convey emotion via facial expression.[1] Multiple disease processes can result in facial nerve dysfunction; however, the result of facial nerve injury is typically flaccid or hypertonic. Patients with flaccid facial paralysis often manifest incomplete eye closure, nasal valve obstruction, and oral incompetence. The development of synkinesis, hypertonicity, and poor voluntary and/or involuntary motor control after facial nerve insult and recovery is termed nonflaccid facial paralysis (NFFP) and, like flaccid facial paralysis, can lead to severe disfigurement and/or disability.[2] Patients with NFFP develop a narrow palpebral fissure, a deepened nasolabial fold, mentalis dimpling, platysmal tightness, and frequently a smile that does not have meaningful excursion even with maximal effort. Both groups of patients experience a disruption in normal facial function and altered facial expressions, especially with smiling.

Loss of the ability to smile can negatively affect both personal and societal perceptions. Utility outcome scores used in a healthy population determined that, if faced with unilateral facial paralysis, individuals reported that they would undergo facial reanimation procedures with a willingness to sacrifice 8 years of life and undergo a procedure with a 21% mortality rate to attain perfect health.[3] In addition, research has shown that society's perception of patients with facial paralysis is negatively altered, which may adversely affect personal and professional relationships.[4] Moreover, laypeople are able to detect as little as 3 mm of facial asymmetry of the oral commissure at rest.[5] This research speaks to the substantial adversity that patients with facial disfigurement may experience; however, it does not directly address patient-perceived disability.

The Facial Clinimetric Evaluation (FaCE) scale is a validated patient-based instrument designed to measure facial impairment and disability, and it permits clinicians to effectively analyze disease-specific quality of life (QOL).[6] The instrument has been used in previous research to show the adverse consequences of synkinesis[7] and the benefits of periocular surgery on QOL.[8] A recent systematic review of patient-reported outcome measures for facial paralysis reported that the FaCE scale is 1 of only 3 questionnaires that satisfied the authors' inclusion criteria.[9]

The high surgical success rates of FGMT for patients with flaccid facial paralysis and NFFP have been reported[10-14]; however, the effect on disease-specific QOL of successful smile reanimation surgery for patients with facial paralysis has not been thoroughly investigated. The primary aim of this report was to determine quantitatively whether FGMT improves QOL in patients with facial paralysis. The secondary aim was to assess whether a difference exists in QOL improvement in patients who underwent an FGMT innervated by a cross-face nerve graft (facial cohort) as compared with patients with an FGMT innervated by the masseteric branch of the trigeminal nerve (trigeminal cohort) and between patients with flaccid paralysis as compared with NFFP.

Methods

This study was approved by the institutional review board at the Massachusetts Eye and Ear Infirmary. A waiver of informed consent was obtained because all the surveys are used as a part of routine clinical care. Prospective analysis was performed on patients presenting to a multidisciplinary facial nerve center from June 2009 to March 2013. A retrospective medical record review was additionally performed for patients evaluated between March 2003 and May 2009. All patients were evaluated in the facial nerve center by a facial plastic surgeon (T.A.H.); underwent a thorough history and physical examination, still photography, and video analysis; and answered a FaCE scale survey. Patients with flaccid facial paralysis who were appropriate free-tissue transfer patients were offered FGMT either through a 1-stage (trigeminal innervation) or 2-stage procedure (innervated by cross-face nerve graft). Patients with NFFP who continued to experience poor recovery of facial nerve function at least 3 months after insult were referred to the facial nerve physical therapist for evaluation and treatment. Patients evaluated and treated during this period who did not develop meaningful oral commissure excursion (defined as <2 mm of oral commissure excursion with smile) and expressed a desire for treatment to improve their smiles were offered FGMT. Participants were observed postoperatively by a facial plastic surgeon and a facial nerve physical therapist, and they continued their preoperative physical therapy and chemodenervation treatment regimens. Postoperative photographs and FaCE surveys were taken after 6 months for a single-stage FGMT and after 12 to 18 months when a 2-stage procedure was performed (cross-face nerve graft followed by FGMT). The photographs were analyzed using the Facial Assessment by Computer Evaluation software (FACE-gram),[15,16] which uses 2-dimensional photographs to accurately measure facial movements including oral commissure excursion. The FACE-gram was used to calculate the c-score (the distance from the midline of the lower lip to the oral commissure) and the angle of oral commissure elevation on the affected and unaffected sides. The level of symmetry was calculated as the millimeter difference between the c-scores on the unaffected and affected sides. The procedure was considered to be a failure if the oral commissure excursion was calculated to be less than 3 mm 6 months after a 1-stage FGMT innervated by the trigeminal nerve and 18 months after a 2-stage procedure with the FGMT innervated by a cross-face nerve graft.

Preoperative and postoperative comparisons of continuous variables were performed using a 2-tailed paired *t* test. For continuous variables with a nonparametric distribution, a Wilcoxon signed-rank test was used. All statistical analysis was performed using STATA/SE, version 12.1 (StataCorp).

Results

Of the approximately 2000 patients evaluated in the Massachusetts Eye and Ear Infirmary Facial Nerve Center between March 2003 and March 2013, 154 FGMTs were performed on 148 patients. One hundred thirty-four FGMTs were performed on patients with flaccid facial paralysis, and 20 were performed on patients with NFFP who were unable to achieve a meaningful smile (≥2 mm oral commissure excursion) with physical therapy

Table 1. Demographic and Operative Characteristics

Characteristic	Value (N = 66)[a]
Demographic characteristics	
Sex, No. (%)	
Male	25 (38)
Female	41 (62)
Age, mean (SD) [range], y	40.1 (16.7) [14-80]
Motor nerve, No. (%)	
Ipsilateral CN 5	34 (52)
Contralateral CN 7	28 (42)
Ipsilateral CN 5 + contralateral CN 7	4 (6)

Abbreviation: CN, cranial nerve.

[a] Sixty-six flaps on 66 patients.

Table 2. Etiology of Facial Paralysis

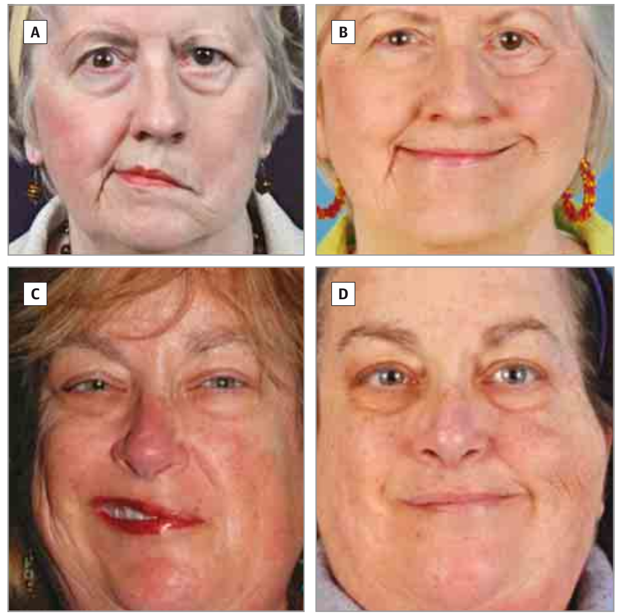
Etiology	No. (%)[a] (N = 66)
Brain tumor	17 (26)
Vestibular schwannoma	13 (20)
Congenital	6 (9)
Malignant parotid neoplasm	5 (8)
Bell palsy	5 (8)
Benign facial nerve neoplasm	4 (6)
Temporal bone fracture	2 (3)
Iatrogenic	2 (3)
Other	12 (18)

[a] Percentages may not total 100% because of rounding.

and/or chemodenervation, and/or platysmectomy. Of the 154 FGMTs performed, 127 FGMTs performed on 124 patients (3 bilateral patients) were determined to be a success (90.9% success rate). Fourteen flaps on 13 patients were determined to be failures (1 patient had 2 failures). Thirteen patients were not included. Of these 13, 7 patients were still in the recovery period at the time of analysis, 4 flaps did not have adequate data to determine success, 1 flap was not performed by one of us (T.A.H.), and 1 flap was too complex of a procedure to be added to the cohort. Of the 127 successful flaps, 6 were on patients with bilateral facial paralysis and 20 patients were younger than 14 years. The FACE-gram results on this patient population were recently reported in a separate article.[17] These results were then used to establish the success and failure cohorts for the present article.

Of the 101 successful flaps on patients with unilateral facial paralysis older than 14 years, 66 patients completed appropriate preoperative and postoperative assessments and are included in the present analysis. Fifty-five flaps were performed on patients with flaccid facial paralysis (flaccid cohort) and 11 on patients with NFFP (NFFP cohort). Thirty-four flaps were innervated by the masseteric branch of the trigeminal nerve (trigeminal cohort), and 28 were innervated by a cross-face nerve graft from the unaffected facial nerve (facial cohort). The demographic and clinical data are presented in **Table 1**. **Table 2** summarizes the etiologies of the facial nerve pathologic mechanism.

Figure. Preoperative and Postoperative Photographs



A, Preoperative, and B, postoperative photographs of a patient with flaccid facial paralysis with smile FaCE score of 31.67 preoperatively and 51.67 postoperatively. C, Preoperative, and D, postoperative photographs of a patient with nonflaccid facial paralysis with smile FaCE score of 56.67 preoperatively and 73.33 postoperatively.

A statistically significant increase in the FaCE score was seen after successful FGMT (paired 2-tailed *t* test, $P < .001$) for all patients. The mean (SD) preoperative and postoperative FaCE scores were 42.30 (15.9) and 58.5 (17.60), respectively. Forty of the 66 patients had adequate preoperative and postoperative photographs to be analyzed with the FACE-gram, and a statistically significant improvement in smile symmetry was found in these participants (paired 2-tailed *t* test, $P < .001$).

The patients were then analyzed by cohort: flaccid, NFFP, trigeminal, facial, and failure. All but the failure cohort demonstrated a statistically significant increase in FaCE score using the paired 2-tailed *t* test. For the flaccid cohort, the mean (SD) preoperative and postoperative FaCE scores were 43.1 (15.1) and 59.6 (17.2), respectively ($P < .001$) (**Figure**, A and B). For the NFFP cohort, the mean (SD) preoperative and postoperative FaCE scores were 37.8 (19.9) and 52.9 (19.3), respectively ($P = .02$) (Figure, C and D). For the trigeminal cohort, the mean (SD) preoperative and postoperative FaCE scores were 38.9 (14.6) and 55.2 (18.2), respectively ($P < .001$). For the facial cohort, the mean (SD) preoperative and postoperative FaCE scores were 47.3 (16.6) and 61.7 (16.9), respectively ($P < .001$). For the failure group, the mean (SD) preoperative and postoperative FaCE scores were 36.5 (20.8) and 33.5 (17.9), respectively ($P = .15$) (**Table 3**).

Comparisons were also made between the trigeminal and facial cohorts and the NFFP and flaccid cohorts. There was found to be a significant difference in preoperative FaCE score between the trigeminal cohort and the facial cohort ($P = .045$)

Table 3. Outcome Assessment

Outcome	No.	Mean (SD)		P Value[a]
		Preoperative	Postoperative	
FaCE Score				
All patients	66	42.3 (15.9)	58.5 (17.6)	<.001
Nonflaccid cohort	11	37.8 (19.9)	52.9 (19.3)	.02
Flaccid cohort	55	43.2 (15.1)	59.6 (17.2)	<.001
Failure cohort	5	36.5 (20.8)	33.5 (17.9)	.15
Trigeminal cohort[b]	34	38.9 (14.6)	55.2 (18.2)	<.001
Facial cohort[c]	28	47.3 (16.6)	61.7 (16.9)	<.001
Excursion, affected side	40	−0.88 (3.79)	7.68 (3.38)	<.001
Symmetry[d]				
At repose	42	5.94 (4.54)	3.96 (3.88)	.04
With smile	40	13.8 (7.48)	4.88 (3.47)	<.001

[a] The *P* values are based on a 2-tailed paired *t* test for samples with n >30 and a Wilcoxon signed-rank test for samples with n <30.

[b] Trigeminal refers to innervation via the ipsilateral masseteric branch of the trigeminal nerve.

[c] Facial refers to innervation from the contralateral facial nerve via a cross-face nerve graft.

[d] Symmetry refers to difference in position relative to midline of lower lip vermillion-cutaneous border between affected and unaffected side, measured in millimeters. Smaller values reflect more symmetry.

Table 4. Quality-of-Life Outcomes in Success Cohort by Nerve Used

Measurement	FaCE Score, Mean (SD)		P Value[c]
	Trigeminal Cohort[a] (n = 34)	Facial Cohort[b] (n = 28)	
Preoperative	38.9 (14.6)	47.3 (16.5)	.045
Postoperative	55.2 (18.2)	61.7 (16.9)	.17

[a] Trigeminal refers to innervation via the ipsilateral masseteric branch of the trigeminal nerve.

[b] Facial refers to innervation from the contralateral facial nerve via a cross-face nerve graft.

[c] The *P* values are based on a Wilcoxon rank-sum test and test the hypothesis that the means for patients in the trigeminal cohort differ from those in the facial cohort.

but not in postoperative FaCE score ($P = .17$) (**Table 4**). Therefore, the change in FaCE score was used to determine whether a quantitative difference in QOL improvement between groups existed. Patients who underwent FGMT innervated by a cross-face nerve graft did not demonstrate a statistically significant difference in the increase in FaCE scores when compared with patients who underwent an FGMT innervated by the trigeminal nerve ($P = .83$). There was not a statistically significant difference in preoperative FaCE score when the flaccid cohort was compared with the NFFP cohort ($P = .17$). In addition, patients with flaccid facial paralysis did not demonstrate a statistically significant difference in the increase in FaCE scores compared with patients with NFFP (mean [SD] change, 16.3 [14.6] vs 15.1 [15.2]; $P = .79$, Wilcoxon rank-sum test).

Discussion

Society's perception of both adults and children with facial disfigurement is often negative. Children with facial disfigurement are perceived as less intelligent by their teachers and often score lower on examinations of psychosocial fitness compared with their peers.[18] As surgeons, we perform various procedures to restore facial appearance to patients with facial disfigurement; however, the outcomes of the procedures are largely judged on our assessment of aesthetic results rather than patient-directed outcomes. Aesthetic goals are often set by the surgeon and assumed to improve social function and societal perception; however, to our knowledge, this assumption has never been directly tested in a large cohort of patients undergoing FGMT for smile reanimation. Advances in quantitative evaluation of disease-specific QOL have made the negative impact of facial nerve dysfunction on QOL more readily apparent.

The FaCE scale instrument, first developed in 2001 by Kahn et al,[6] provides a valid and reliable method for patient-rated assessment of facial paralysis. It has been used extensively in the literature to report QOL improvement after a variety of treatment modalities in patients with both flaccid paralysis and NFFP.[7,8,14,19] A recent systematic review of patient-reported outcome measures determined that the FaCE scale was 1 of only 3 questionnaires among the 28 questionnaires reviewed that satisfied the authors' inclusion and exclusion criteria.[9] The authors concluded that the FaCE scale extensively covered both physical and social functioning but was limited by the use of classical test theory, which assumes that all items contribute equally to the final score. Despite this limitation, it appears to be the best patient-reported outcome measure to assess patients with facial nerve injury.[9]

The surgical success of interventions performed both to improve facial function and to affect facial appearance should not be judged solely on improvement in function but also by patient-reported outcome measures. The goal of this study was to determine whether patient-reported disease-specific QOL improvement is seen after FGMT for facial reanimation in patients with facial paralysis. In addition, we aimed to determine by subgroup analysis whether patients undergoing an FGMT innervated by a cross-face nerve graft had a statistically significant difference in improvement compared with patients who underwent a single-stage procedure with an FGMT innervated by the masseteric branch of the trigeminal nerve. Furthermore, we aimed to determine whether patients with flaccid facial paralysis demonstrated an improved QOL outcome compared with patients with NFFP. The FACE-gram was used to determine functional success or failure on the basis of the amount of oral commissure excursion and smile symmetry.[20] We used the FaCE scale preoperatively and postoperatively to determine the QOL impact of FGMT on this patient population. To our knowledge, this has not been described in the literature except in a small cohort of 17 pediatric patients.[10]

This study demonstrates a statistically significant improvement in disease-specific QOL after FGMT for the management of facial paralysis. As expected, a QOL improvement was also found in all cohorts except for the failure cohort. Interestingly, all cohorts had similar preoperative FaCE scores except for the trigeminal cohort, which had scores statistically significantly lower than those of the other cohorts. One explanation for this difference is that the mean (range) age for the trigeminal cohort (46.3 [14-80]) years was significantly older than that of the facial cohort (33.0 [14-69]; $P = .002$). For many years, one of us (T.A.H.) used the 1-stage procedure almost exclusively in patients older than 30 years. This practice has changed in recent years, as the surgical success rate of the cross-face nerve graft has improved and its use in the older population has therefore increased. This older population may have less functional reserve, and the decreased skin turgor seen with aging may be causing older patients to experience to a greater extent the adverse sequelae of facial paralysis. Clinically, we observe that older patients develop ectropion with associated corneal issues, brow ptosis, and oral incompetence sooner and to a greater extent than young patients. Despite the difference in baseline FaCE score, we discovered that the difference in improvement in QOL between the trigeminal cohort and the facial cohort was not significant ($P = .83$). We would have expected that the patients' having undergone a 2-stage procedure with the gracilis muscle innervated by a cross-face nerve graft performed to generate a spontaneous smile would have led to an improved QOL when compared with undergoing a 1-stage procedure with the muscle innervated by the trigeminal nerve. One possible explanation for this is that only a small difference exists and that over time with additional patients a statistical difference may become evident. Conversely, perhaps the ability to regain a smile—whether spontaneous or not—is the most important factor in smile reanimation. Another possibility is that the patients in the trigeminal cohort are achieving a spontaneous smile.[21] The advent of a validated spontaneous smile assay would permit us to further investigate these findings.

We also investigated possible differences in surgical success in patients with flaccid facial paralysis compared with those with NFFP. Unfortunately, the synkinesis, hypertonicity, and generalized facial motor dysfunction seen in patients with NFFP are often underrecognized and undertreated sequelae of facial nerve insult and recovery. In contrast to patients with flaccid facial paralysis, who manifest incomplete eye closure, nasal valve obstruction, and oral incompetence, patients with NFFP develop a narrow palpebral fissure, a deepened nasolabial fold, mentalis dimpling, platysmal tightness, and frequently a smile that does not have meaningful excursion even with maximal effort. The resulting "frozen face" can be just as disturbing as flaccid facial paralysis, leaving patients unable to convey appropriate emotion and experiencing a decrease in disease-specific QOL.[7] Chemodenervation,[7] platysmectomy,[19] and FGMT[14] have been shown in previous studies from our institution to improve disease-specific QOL in patients with NFFP. In the present study, we found the preintervention FaCE score in patients with NFFP not to be significantly different from that of patients with flaccid facial paralysis ($P = .17$). In addition, their improvement after FGMT was similar ($P = .79$). Whereas the difference in improvement in QOL for patients with flaccid facial paralysis vs NFFP may yield statistically significant results with a larger sample, that statement cannot be made at this time. Alternately, the lack of significant difference in rate of improvement may stem from the substantial impairment that patients with NFFP incur.

Whereas the present study uses validated disease-specific patient-reported outcome measures, validated facial measurement tools, a standardized treatment plan, and a clinical follow-up rate of 95%, its shortcomings include that it was not randomized, it reports a single-institution experience, and it did not correlate subjective outcome measures to objective measures. In addition, although the patient follow-up rate was 95%, only 66 of 101 participants (65%) completed preoperative and postoperative FaCE scales at appropriate time intervals. We are in the process of implementing electronic data entry using RedCap to improve response rate. RedCap will send automated e-mails at specific postoperative time points. The goal is to improve data capture, which is complicated by the use of paper questionnaires, staff changes, and the participation of international and/or nonregional patients. Future work must involve increasing our own response rate and facilitating multi-institutional research. Only with the pooling of multi-institutional data through a uniform data entry process will facial reanimation surgeons achieve investigations appropriately powered to determine the improvement in smile function required for a QOL benefit.

Conclusions

Free gracilis muscle transfer has become a mainstay in the management armamentarium for patients who develop a severe reduction in oral commissure movement after facial nerve insult. The operation achieves a high overall success rate.[17] This study demonstrates a quantitative improvement in quality of life after successful FGMT in patients who failed to recover a meaningful smile after facial nerve insult. Quality-of-life improvement was not statistically different between donor nerve groups or between patients with flaccid and nonflaccid facial paralysis.

ARTICLE INFORMATION

Accepted for Publication: June 3, 2014.

Published Online: October 2, 2014. doi:10.1001/jamafacial.2014.679.

Author Contributions: Drs Lindsay and Hadlock had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.
Study concept and design: All authors.
Acquisition, analysis, or interpretation of data: Bhama, Hadlock.
Drafting of the manuscript: Lindsay.
Critical revision of the manuscript for important intellectual content: All authors.
Statistical analysis: Bhama.
Obtained funding: Lindsay.
Administrative, technical, or material support: Lindsay, Hadlock.
Study supervision: Lindsay, Hadlock.

Conflict of Interest Disclosures: None reported.

Funding/Support: The work was supported in part by the Leslie Bernstein Grant from the American Academy of Facial Plastic and Reconstructive Surgery.

Role of the Funder/Sponsor: The American Academy of Facial Plastic and Reconstructive Surgery had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

Additional Contributions: Kate Horstkotte, BA, and Kerry Shanley, PA, Massachusetts Eye and Ear Infirmary, provided assistance with data entry and retrieval. They were not compensated for their contribution.

REFERENCES

1. Peitersen E. Bell's palsy: the spontaneous course of 2,500 peripheral facial nerve palsies of different etiologies. *Acta Otolaryngol Suppl*. 2002;(549):4-30.

2. Mehta RP, WernickRobinson M, Hadlock TA. Validation of the Synkinesis Assessment Questionnaire. *Laryngoscope*. 2007;117(5):923-926.

3. Sinno H, Thibaudeau S, Izadpanah A, et al. Utility outcome scores for unilateral facial paralysis. *Ann Plast Surg*. 2012;69(4):435-438.

4. Ishii L, Godoy A, Encarnacion CO, Byrne PJ, Boahene KD, Ishii M. Not just another face in the crowd: society's perceptions of facial paralysis. *Laryngoscope*. 2012;122(3):533-538.

5. Chu EA, Farrag TY, Ishii LE, Byrne PJ. Threshold of visual perception of facial asymmetry in a facial paralysis model. *Arch Facial Plast Surg*. 2011;13(1):14-19.

6. Kahn JB, Gliklich RE, Boyev KP, Stewart MG, Metson RB, McKenna MJ. Validation of a patient-graded instrument for facial nerve paralysis: the FaCE scale. *Laryngoscope*. 2001;111(3):387-398.

7. Mehta RP, Hadlock TA. Botulinum toxin and QOL in patients with facial paralysis. *Arch Facial Plast Surg*. 2008;10(2):84-87.

8. Henstrom DK, Lindsay RW, Cheney ML, Hadlock TA. Surgical treatment of the periocular complex and improvement of quality of life in patients with facial paralysis. *Arch Facial Plast Surg*. 2011;13(2):125-128.

9. Ho AL, Scott AM, Klassen AF, Cano SJ, Pusic AL, Van Laeken N. Measuring quality of life and patient satisfaction in facial paralysis patients: a systematic review of patient-reported outcome measures. *Plast Reconstr Surg*. 2012;130(1):91-99.

10. Hadlock TA, Malo JS, Cheney ML, Henstrom DK. Free gracilis transfer for smile in children: the Massachusetts Eye and Ear Infirmary experience in excursion and quality-of-life changes. *Arch Facial Plast Surg*. 2011;13(3):190-194.

11. Bae YC, Zuker RM, Manktelow RT, Wade S. A comparison of commissure excursion following gracilis muscle transplantation for facial paralysis using a cross-face nerve graft versus the motor nerve to the masseter nerve. *Plast Reconstr Surg*. 2006;117(7):2407-2413.

12. Zuker RM, Goldberg CS, Manktelow RT. Facial animation in children with Möbius syndrome after segmental gracilis muscle transplant. *Plast Reconstr Surg*. 2000;106(1):1-9.

13. Biglioli F, Colombo V, Tarabbia F, et al. Double innervation in free-flap surgery for long-standing facial paralysis. *J Plast Reconstr Aesthet Surg*. 2012;65(10):1343-1349.

14. 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.

15. Bray D, Henstrom DK, Cheney ML, Hadlock TA. Assessing outcomes in facial reanimation: evaluation and validation of the SMILE system for measuring lip excursion during smiling. *Arch Facial Plast Surg*. 2010;12(5):352-354.

16. Hadlock TA, Urban LS. Toward a universal, automated facial measurement tool in facial reanimation. *Arch Facial Plast Surg*. 2012;14(4):277-282.

17. Bhama P, Gliklich RE, Weinberg JS, Hadlock TA, Lindsay RW. Optimizing total facial nerve patient management for effective clinical outcomes research. *JAMA Facial Plast Surg*. 2014;16(1):9-14.

18. Stubbs TK, James LE, Daugherty MB, et al. Psychosocial impact of childhood face burns: a multicenter, prospective, longitudinal study of 390 children and adolescents. *Burns*. 2011;37(3):387-394.

19. Henstrom DK, Malo JS, Cheney ML, Hadlock TA. Platysmectomy: an effective intervention for facial synkinesis and hypertonicity. *Arch Facial Plast Surg*. 2011;13(4):239-243.

20. 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.

21. 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.