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PRS GLOBAL OPEN

ORIGINAL ARTICLE
Peripheral Nerve

Electrophysiological Changes in Patients with Postoperative Cross-facial Nerve Graft in a Tertiary Care Center

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Background: Facial nerve palsy is a multifaceted pathology that causes facial disfigurement, affecting eye closure, speech articulation, oral competence, and emotional expression, with functional, aesthetic, and psychological consequences. Standardized electrophysiological tests, such as electroneurography and electromyography, allow an objective evaluation of the functional state of the nerve. Here, we aimed to compare and correlate clinical findings with electromyography in patients with facial nerve palsy, before and after facial nerve reanimation with cross-facial nerve grafts.
Methods: Eight patients with traumatic or nontraumatic facial paralysis with complete clinical records who underwent surgical reanimation of facial nerve with cross nerve grafts.
Results: The median time from diagnosis to treatment was 173 days (interquartile range = 222). Outcomes were evaluated using standard clinical scales (House-Brackmann, Sunnybrook, and eFACE) and electromyography. The median time for postoperative outcome evaluation was 768 days (interquartile range = 1053). A statistically significant difference was found between pre- and postoperative outcomes according to eFACE (Δ median = 13, $P = 0.003$), House-Brackmann (Δ median = −2, $P = 0.008$), and electromyography (Δ mean = 855, $P = 0.005$). A positive correlation between electromyography and clinical evaluation with eFACE was observed ($r = 0.751$, 95% confidence interval = 0.174–0.944, $P = 0.019$).
Conclusions: Our results suggest that cross nerve grafts are associated with clinical and electromyographic improvement of the paralyzed face. Electromyography and eFACE scores validate the reliability of eFACE scale for measuring postoperative outcomes. We suggest postoperative electromyography as an objective measure of postoperative evaluation in patients with a delay in improvement at 6–9 months.
(Plast Reconstr Surg Glob Open 2024; 12:e5973; doi: 10.1097/GOX.0000000000005973; Published online 15 July 2024.)

INTRODUCTION

Facial nerve palsy is a challenging condition that impacts a significant number of people each year, with an estimated 20–30 cases per 100,000 individuals. This condition results in the loss of control and innervation of the facial muscles, leading to weakness that can affect various functions such as speech, oral competency, vision, and the ability to express emotions. The consequences of facial nerve palsy can have a profound impact on the quality of life for those affected because it can hinder everyday activities and interactions.[1] There is a wide range of etiologies that can cause facial palsy, including iatrogenic, neoplastic, neurologic, congenital, inflammatory, idiopathic, and traumatic causes.

A proper diagnosis of facial palsy should include a complete evaluation of facial function, both static and dynamic.[2] Electrophysiological examination allows us to evaluate the functional state of the nerve through standardized diagnostic tests, such as electroneurography and electromyography (EMG). Several key aspects have a significant role in guiding the therapeutic approach for facial palsy, such as the time that has elapsed since the

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Received for publication March 27, 2024; accepted May 16, 2024.

DOI: 10.1097/GOX.0000000000005973

Disclosure statements are at the end of this article, following the correspondence information.

injury occurred, age, comorbidities, and the results of electrophysiological studies.

Surgical rehabilitation for cases in which the proximal facial nerve is not viable for reconstruction often involves cross-facial nerve grafting (CFNG). This procedure is typically performed when the distal portion of the affected facial nerve and the associated muscles are still intact. This involves a functional branch of the opposite facial nerve to anastomose the affected distal branch. CFNG is the current state of the art for facial reanimation.[3,4]

The assessment of surgical success in patients with facial paralysis often relies on subjective clinical scales rather than objective evidence like electrophysiological studies. This study aims to bridge this gap by correlating clinical findings with EMG results in patients undergoing surgical facial nerve resuscitation with CFNG. By evaluating the EMG data before and after the procedure, researchers can provide a more comprehensive understanding of the changes in facial nerve function after surgery. This correlation can enhance the accuracy and reliability of assessing surgical outcomes, leading to improved patient care and treatment strategies for individuals with facial paralysis.

Takeaways

Question: What are the electromyographic changes with the use of cross nerve grafts in patients with facial palsy and how do they correlate with clinical grading scales?

Findings: In this study, we found important electromyographic changes after surgery with insignificant correlation with House-Brackmann and Sunnnybrook, and good correlation with eFACE.

Meaning: We suggest the use of postoperative electromyography as an objective parameter to evaluate cross-facial nerve grafting in addition to clinical grading scales in cases where it is necessary to assess the presence of reinnervation as a form of feedback for the surgeon and the patient. The eFACE score had the highest correlation with electromyography and thus could represent a useful proxy for evaluating clinical improvement.

MATERIALS AND METHODS

We designed a retrospective descriptive study—approved by our institutional review board—that focuses on patients with nontraumatic and traumatic facial palsy. The inclusion criteria include patients with confirmed diagnosis through physical examination and electrophysiological studies, specifically those who have not undergone any facial surgery or reanimation procedure. Clinical examination was evaluated using three grading systems for facial nerve function: House-Brackmann (HB), Sunnybrook (SB), and electronic clinician graded facial function scale (eFACE).[5–8] Preoperative electrophysiological testing (electroneurography and EMG) and CFNG were performed in all patients, followed by postoperative EMG. Records with incomplete photographic and video evidence were excluded.

Surgical Technique

The sural nerve was harvested through three equidistant 3-cm longitudinal incisions starting between the lateral malleolus and the Achilles tendon and continuing proximally through the course of the nerve. The sural nerve was in the deep aspect of the subcutaneous fat and was dissected from the lesser saphenous vein. After distal transection of the sural nerve, it was mobilized from distal to proximal.[9] Vessel loops were used to aid in handling and prevent injury. Multiple smaller longitudinal incisions were made with undermining and retraction while working under the skin islands. The graft was fully mobilized but remained in situ until ready for transfer to the recipient site. Before use, the proximal end was marked and the graft was inverted.[3] A subcutaneous pathway was developed between both sides of the face. The nerve was sutured to a vessel loop and passed to the contralateral face with a nerve dissector. On the unaffected side of the face, a preauricular incision was made, and the skin flap was dissected anteriorly until the buccal and zygomatic branches were identified using an electrical stimulator (NIM-Neuro 3.0 Nerve Monitor eight channels of nerve muscle combinations; Medtronic, Dublin, Ireland). Distal branches demonstrating effective eye closure and oral commissure movement were used for the primary anastomosis.[3] The same procedure was performed contralaterally, followed by side-to-side anastomoses between these branches.

We performed the harvest of the sural nerve, as well as facial surgical exploration, dissection and preparation of the branches of the facial nerve with magnification loupes (3.5X, Designs for Vision, N.Y.). Coaptation of the nerve grafts was carried out under the magnification of the Zeiss OPMI Pentero 900 microscope (Jena, Germany) using two suture knots of 9-0 nylon Ethicon (N.J.) and Tisseel Baxter (Ill.) at each end.

All procedures were performed by the same surgeon, and in cases when an additional procedure was needed to achieve a better outcome, it was performed according to the surgeon's criteria. For patient 1, a gold eyelid weight was placed, and patient 7 received botulinum toxin. Patient 8 required the most interventions; this patient underwent a babysitter procedure, a gold eyelid weight was placed, and an orthodromic transfer of the temporalis muscle was performed.

Electromyography

EMG was performed at the first visit and at least 5 months after reanimation. A standard technique was used, consisting of electrode placement in the orbicularis oculi, nasalis, and orbicularis oris. The patient was then asked to contract the muscle to assess spontaneous activity, motor unit action potential, and maximum voluntary activity. All tests were recorded with the same equipment (4 channel 25 mm monopolar needle; Nicolet Viking Quest EMG, San Diego, Ca.) and the same staff.

Statistical Analysis

Statistical analysis was carried out using R version 4.3.2 (R Foundation for Statistical Computing, Vienna, Austria). Clinical and demographic variables were analyzed using

Table 1. Characteristics of the Study Population

Case No.	Sex and Age at Time of Nerve Crossing		Laterality	Etiology	Interval between Paralysis and Nerve Anastomosis, d	Time Elapsed from Intervention to EMG Performance, d	Additional Procedures
1	M	57	Left	Traumatic (laceration injury)	90	1401	Gold eyelid weight
2	F	25	Left	Nontraumatic (Bell palsy)	200	933	No
3	F	4	Right	Nontraumatic (congenital facial palsy)	1548	530	No
4	F	44	Right	Traumatic (temporal bone fracture)	146	604	No
5	F	30	Left	Traumatic (temporal bone fracture)	143	413	No
6	F	4	Left	Nontraumatic (Bell palsy)	463	150	No
7	F	71	Right	Traumatic (total parotidectomy)	142	1485	Botulinum toxin
8	F	47	Right	Traumatic (postresection of cerebellopontine angle meningioma)	332	1436	"Babysitter" procedure + gold eyelid weight + orthodromic transfer of the temporalis muscle
N = 8	F = 7 (88%) M = 1 (13%)	Median 35 (4, 71)	L = 4 (50%) R = 4 (50%)	Traumatic = 5 (62%) Nontraumatic = 3 (38%)	Median 173 (90, 1548) IQR = 222	Mean = 2.2 y SD = 1.5	

n (%), median (range).
The median time from diagnosis to treatment was 173 d.

the Shapiro-Wilk test to determine their distribution and presented using mean or median and their corresponding dispersion measures. The statistical significance threshold was set as a P value of less than 0.05. The change (delta) between pre- and postoperative clinical (HB, SB, and eFACE) and EMG measurements was calculated using the following formula:

$$\Delta = \sum_{\text{postsurgical}} - \sum_{\text{presurgical}}$$

The changes in pre- and postoperative clinical scores and EMG measurements were evaluated using paired samples Student t test for parametric data and Wilcoxon signed rank test for nonparametric data. The correlation between postoperative measurements was evaluated using Pearson or Spearman rank correlation.

RESULTS

A total of eight patients were included, nontraumatic etiologies were congenital facial palsy (one, 12.5%) and Bell palsy (two, 25%), the rest were considered post-traumatic including temporal bone fracture (two, 25%), laceration injury (one, 12.5%), postresection of cerebellopontine angle meningioma (one, 12.5%), and total parotidectomy (one, 12.5%). The time from diagnosis to treatment ranged from 90 to 1548 days with a median of 173 days. All characteristics of the study population are shown in Table 1.

Facial Function Scales

When referring to improvement in clinical scales, we consider improvement to be any positive change within the HB, SB, and eFACE clinical scales. Seven of eight patients had a statistically significant improvement in their postoperative clinical scores with HB (median Δ = -2, P = 0.008), eFACE (median Δ = 13, P = 0.003), and SB (mean Δ = 18.12, P = 0.018) (Table 2). One patient had no significant changes on either static or dynamic testing.

EMG Studies

The EMG score was calculated by averaging the maximum amplitude of voluntary activity for each muscle studied (orbicularis oculi, nasalis, and orbicularis oris). The preoperative median score was 625.6 [interquartile range (IQR) 507.1–833.5], postoperative median was 1654.5 (IQR 1534.2–1664.9) with a statistically significant improvement of 913.67 (IQR 822.4–966.3) (P = 0.003). Only one patient showed no improvement in EMG. However, facial functional scales improved (Fig. 1, Table 2). We did not observe any postoperative complications in our study.

Correlations between Postoperative Outcome Measurements

The correlation between postoperative outcomes measured by all clinical scores and EMG was evaluated. A strong, positive and significant correlation between postoperative eFACE and EMG was found (Pearson correlation coefficient = 0.751, P = 0.019, 95% confidence interval, 0.17–0.94). Additionally, a strong, negative correlation between postoperative Sunnybrook and HB scores was found (Spearman correlation = −0.908, P < 0.01).

DISCUSSION

Facial palsy is a challenging condition that can have significant impacts on various aspects of a person's life.

Table 2. Difference between Pre- and Postsurgical Scores Measured by HB, SB, eFACE and EMG

	HB		SB		eFACE		EMG*	
Patient	Presurgical Score	Postsurgical Score	Presurgical Score	Postsurgical Score	Presurgical Score	Postsurgical Score	Presurgical Score	Postsurgical Score
1	5	2	15	63	74.17	88.67	778	1664.67
2	4	2	51	65	86.67	93.17	1000	1665.67
3	4	2	67	73	90.50	98.33	257.67	1644.33
4	5	3	8	37	54.83	92.50	610	1557.33
5	4	2	37	67	64.50	89.50	590.33	1465
6	4	4	40	22	65.67	81.83	641.33	1664.67
7	4	2	40	66	82.83	94.33	1800	2740.67
8	6	4	22	32	62.33	70.67	120	241.33
Mean, difference (%)	4.50	2.62	35	53.12	72.69	88.62	625.6	1654.5
	Δ median = −2 *P* = 0.0156†		Δ mean = 18.12 *P* = 0.0361‡		Δ mean = 15.94 *P* = 0.0038‡		Δ mean = 855 *P* = 0.0003‡	

*The EMG score was calculated by averaging the maximum amplitude of voluntary activity of each muscle (orbicularis oculi, nasalis, and orbicularis oris).
†Wilcoxon matched-pairs signed rank test.
‡Paired *t* test

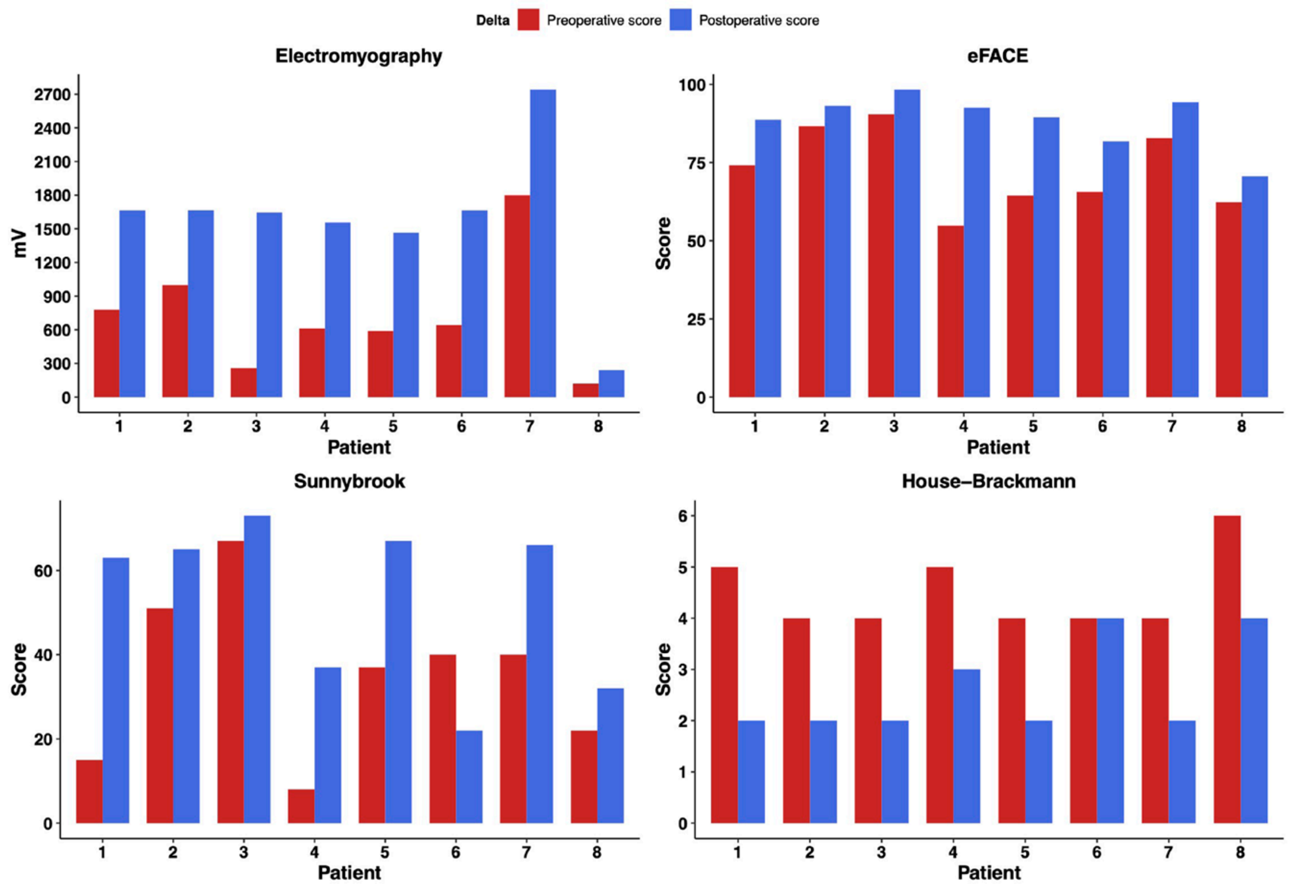

Fig. 1. Comparison of the clinical grading scales before and after the surgery.

It not only leads to facial disfigurement but also affects essential functions such as eye closure, speech articulation, oral competence, and emotional expression. These effects can have profound consequences on individuals, impacting their functionality, appearance, and psychological well-being.

The HB scale was used because it is the most historically accepted and widely known, but we believe that for reanimation procedures, it is important to use more detailed scales. Sunnybrook and eFACE were used for their diagnostic validity and to support electrophysiological studies reporting facial nerve functional status. A study by Terzis and Konofaos[10] reported good and excellent results in 72% of hemifaces for overall functional status; evaluating reconstruction only with CFNGs, 36.06% had excellent or good results. They observed that younger patients (younger than

35 years) and earlier cases had better results.[10] Another report by Terzis and Konofaos[11] showed good and excellent scores in 50% of CFNG patients. Our study shows success rates similar to the latter. CFNG is known to be a safe and effective procedure with good objective and clinical improvement shown by EMG and facial scales. We chose to correlate clinical findings with EMG results in patients who underwent CFNG to determine which scale better represents the functional state of the facial nerve. Postoperative eFACE scores are highly correlated with EMG, supporting its use as a proxy for clinical improvement in facial nerve reanimation procedures. The interval between CFNG, electromyography, and clinical evaluation ranged from 150 to 1486 days, with most patients showing significant improvement at evaluation. However, there were two particular cases, patients 6 and 8, in whom there were changes in the facial function scales that did not correlate with the electromyography results. In particular, patient 8 had evident improvement on physical examination, but there was no evidence of reinnervation on EMG (preoperative EMG 120 versus postoperative EMG 241.33). This result was due to other procedures such as a "babysitter" procedure followed by CFNG and gold weight eyelid surgery without significant improvement; therefore, we performed an orthodromic transfer of the temporalis muscle one year later, which significantly improved clinical scores (HB preoperative 6 versus 4 postoperative, SB preoperative 22 versus 32 postoperative, eFACE preoperative 62.33 versus 70.67 postoperative). We hypothesize that given the nature of the paralysis, which occurred after resection of a meningioma in the pontocerebellar angle and the time from the onset of paralysis until reinnervation surgery, which was performed almost a year after the resection, the motor plates were damaged by lack of mobility secondary to loss of nerve stimulation. In contrast, patient 6 had noticeable EMG changes (EMG preoperative 641.33 versus 1664.67 postoperative) but no improvement on physical examination (preoperative HB 4 versus postoperative HB 4, SB 40 preoperative versus 22 postoperative, eFACE preoperative 65.67 versus 81.83 postoperative). We believe that the lack of clinical changes in patient 6 may be due to the time elapsed between surgery and EMG, which was the shortest at almost 5 months postoperative.

Limitations of the Study

Limitations of this study are retrospective analysis, use of other reanimation techniques, small sample size, and the fact that patients did not have EMG testing at the same time interval.

CONCLUSIONS

We suggest the use of postoperative EMG as an objective parameter to evaluate CFNG in addition to clinical grading scales in cases where it is necessary to assess the presence of reinnervation as a form of feedback for the surgeon and the patient. Regarding the use of clinical scales for postoperative evaluation, the eFACE score had the highest correlation with EMG and, thus, could represent a useful proxy for evaluating clinical improvement. It is important to note that many of these patients may require additional procedures to achieve a more harmonious facial symmetry. Although CFNG has been shown to be safe and effective in restoring muscular function, EMG can provide information regarding the progress of rehabilitation, particularly in patients who experience a delay in improvement at 6 to 9 months, a period during which clinical improvement is anticipated.

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DISCLOSURE

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

REFERENCES

1. Razfar A, Lee MK, Massry GG, et al. Facial paralysis reconstruction. *Otolaryngol Clin North Am.* 2016;49:459–473.
2. Lee D-H. Clinical efficacy of electroneurography in acute facial paralysis. *J Audiol Otol.* 2016;20:8–12.
3. Lu GN, Flynn J. Facial nerve reconstruction. *Otolaryngol Clin North Am.* 2023;56:757–767.
4. Terzis JK, Konofaos P. Nerve transfers in facial palsy. *Facial Plast Surg.* 2008;24:177–193.
5. Neely JG, Cherian NG, Dickerson CB, et al. Sunnybrook facial grading system: reliability and criteria for grading. *Laryngoscope.* 2010;120:1038–1045.
6. House JW, Brackmann DE. Facial nerve grading system. *Otolaryngol Head Neck Surg. 1985*;93:146–147.
7. Banks CA, Bhama PK, Park J, et al. Clinician-graded electronic facial paralysis assessment: the eFACE. *Plast Reconstr Surg.* 2015;136:223e–230e.
8. Banks CA, Jowett N, Azizzadeh B, et al. Worldwide testing of the eFACE facial nerve clinician-graded scale. *Plast Reconstr Surg.* 2017;139:491e–498e.
9. Peng GL, Azizzadeh B. Cross-facial nerve grafting for facial reanimation. *Facial Plast Surg.* 2015;31:128–133.
10. Terzis JK, Konofaos P. Experience with 60 adult patients with facial paralysis secondary to tumor extirpation. *Plast Reconstr Surg.* 2012;130:51e–66e.
11. Terzis JK, Konofaos P. Reanimation of facial palsy following tumor extirpation in pediatric patients: our experience with 16 patients. *J Plast Reconstr Aesthet Surg.* 2013;66:1219–1229.