Cross-Face Nerve Grafting for Reanimation of Incomplete Facial Paralysis: Quantitative Outcomes Using the FACIAL CLIMA System and Patient Satisfaction

Bernardo Hontanilla, MD, PhD[1] Diego Marre, MD[1] Alvaro Cabello, MD[1]

[1] Department of Plastic and Reconstructive Surgery, Clinica Universidad de Navarra, Pamplona, Spain

J Reconstr Microsurg 2014;30:25–30.

Address for correspondence Bernardo Hontanilla, MD, PhD, Department of Plastic and Reconstructive Surgery, Clinica Universidad de Navarra, Avenida Pio XII 36, 31008, Pamplona, Spain (e-mail: bhontanill@unav.es).

Abstract

Although in most cases Bell palsy resolves spontaneously, approximately one-third of patients will present sequela including facial synkinesis and paresis. Currently, the techniques available for reanimation of these patients include hypoglossal nerve transposition, free muscle transfer, and cross-face nerve grafting (CFNG). Between December 2008 and March 2012, eight patients with incomplete unilateral facial paralysis were reanimated with two-stage CFNG. Gender, age at surgery, etiology of paralysis denervation time, donor and recipient nerves, presence of facial synkinesis, and follow-up were registered. Commissural excursion and velocity and patient satisfaction were evaluated with the FACIAL CLIMA and a questionnaire, respectively. Mean age at surgery was 33.8 ± 11.5 years; mean time of denervation was 96.6 ± 109.8 months. No complications requiring surgery were registered. Follow-up period ranged from 7 to 33 months with a mean of 19 ± 9.7 months. FACIAL CLIMA showed improvement of both commissural excursion and velocity greater than 75% in 4 patients, greater than 50% in 2 patients, and less than 50% in the remaining two patients. Qualitative evaluation revealed a high grade of satisfaction in six patients (75%). Two-stage CFNG is a reliable technique for reanimation of incomplete facial paralysis with a high grade of patient satisfaction.

Keywords

- incomplete facial paralysis
- cross-face nerve graft
- FACIAL CLIMA

Bell palsy is an acute, idiopathic, and usually unilateral facial paralysis being the most frequent acquired etiology of facial paralysis with an incidence of 20 to 30 cases per 100,000 people per year.[1] Typically, Bell palsy resolves spontaneously in about two-third of patients within the first 6 months after onset. The remaining one-third have an incomplete recovery characterized by a symmetrical tone at rest but with muscular weakness, motor synkinesis and hemifacial spams at movement leaving undesired cosmetic sequela in some cases.

Despite the efforts of different authors to satisfactorily treat incomplete long-standing facial paralysis, this group of patients still remains a challenge. Options of reanimation in these cases include hypoglossal-facial nerve transfer, one-stage muscle transfer, and cross-face nerve grafting (CFNG).[2–7] As other authors,[4–6] we employ mainly the CFNG. Since its original description by Scaramella and Tobias in the 1970s,[8] different modifications have been reported for CFNG such as the two-stage technique introduced by Anderl.[9] Following this procedure, after the first step, the axons grow through the CFNG, and in a second step, the distal stump is connected to the distal stump of the paretic facial nerve branches. By performing the procedure in two stages, we avoid the growing of axons from the affected side into the nerve graft. Notwithstanding, the essence of the procedure remains unchanged, which is

received
January 14, 2013
accepted after revision
June 2, 2013
published online
July 1, 2013

DOI http://dx.doi.org/10.1055/s-0033-1349347.
ISSN 0743-684X.

borrowing axons from the healthy side that will act as the pacemakers of the affected side.

An important aspect to consider when performing CFNG for reanimation of incomplete facial paralysis is to avoid adding further damage to the paralyzed side when transecting the branches selected for reinnervation. Although authors agree that with an end-to-end coaptation, an adequate neurotization with minimal damage can be obtained,[4,5] and end-to-side connection (on the partially paralyzed side) has been advocated as a means of maximally preventing injury to any remaining axons.[6] Furthermore, the axonal load provided by the donor nerve has also been a matter of investigation regarding CFNG with authors describing a direct correlation between the number of axons of the donor nerve and the functional and aesthetic outcomes.[4] Altogether, different authors agree that for incomplete paralysis, CFNG is a reliable technique of reanimation.[4–6]

However, less consensus exists regarding an accurate measurement system in dynamic reanimation of facial paralysis. Parallel to the development of surgical techniques for rehabilitation, numerous systems have been described. Traditionally, the House–Brackmann scale has been used; however, it has the problem that assesses the degree of facial paralysis only in qualitative terms and is an observer-dependent method.[10] Other quantitative systems have been described but none have been accepted for clinical use so far.[11–13] In 2008, we developed an automatic, easy, reproducible, fast, quantitative method called FACIAL CLIMA that provides dynamic three-dimensional information allowing comparison of results obtained after reanimation with different surgical techniques.[14–16]

This study describes our experience using two-stage CFNG for incomplete facial palsy evaluating the outcomes in quantitative and qualitative terms with the FACIAL CLIMA system correlated with patient satisfaction.

Patients and Methods

Between December 2008 and March 2012, eight patients (two male and six female patients) with incomplete unilateral facial paralysis were reanimated with CFNG in our institution. All surgeries were performed by the senior author (B.H.) after a minimum of 12 months of no electrophysiological recovery and clinical improvement. For all patients, gender, age at surgery, etiology of disease, time of evolution, donor and recipient nerve, and complications were registered.

Quantitative Evaluation: FACIAL CLIMA

FACIAL CLIMA is an automatic optical system to capture facial movements, which involves placing special reflecting dots on the subject's face following a predetermined configuration. A system of video recording with three infrared-light cameras captures the subject performing the following movements: smiling, mouth puckering, eye closure, and forehead elevation. With these four movements, several vectors are obtained and analyzed. Images from the cameras are automatically processed by computer software that generates customized information such as three-dimensional data on velocities, distances, and areas. The accuracy of the measurement process is between 0.13 mm and 0.41 degree. This system has been tested in normal patients and found to have a reliability of 99%. For more information about intrarrater and interrater accuracy and exact functioning of this system, please refer to the study by Meier-Gallati et al.[13]

To evaluate recovery of smile following CFNG, the following parameters were evaluated in each patient by means of the FACIAL CLIMA system: commissural contraction velocity (CCV, mm/s) (mean of maximum velocity of contraction) and oral commissure displacement (CD, mm) (mean difference between the minimum and maximum commissural displacement at rest and when contracted). Both parameters were obtained from the normal and reanimated side. Patients are analyzed 1, 3, 6, 12, and 24 months after surgery. Because all the patients were presented with incomplete facial paralysis, first the preoperative values of both CCV and CD on the paralyzed side were subtracted to those obtained on the normal side. Then, on follow-up, recovery was registered as the percentage of reduction of the preoperative difference. For example, a patient with a difference of 4 mm in commissural displacement between both sides preoperatively that after surgery shows a 2 mm difference is considered to have a recovery of 50%.

Qualitative Evaluation: Questionnaire

For qualitative evaluation, patients were contacted by telephone and asked following three questions regarding the outcome of surgery: (1) Are you satisfied with the result? (2) Would you undergo surgery again? (3) What is your overall rating of the procedure (0, *very poor*; 1, *poor*; 2, *fair*; 3, *good*; 4, *very good*; 5, *excellent*)?

Operative Technique

First Stage

In all cases, a sural nerve graft of 18 to 22 cm in length was harvested from the nondominant side by means of two or three horizontal incisions on the posterolateral aspect of the leg. Simultaneously, through a preauricular incision on the normal side, a cheek flap was raised with a supra—superficial muscle aponeurotic system dissection to identify the anterior margin of the parotid gland in which the branches of the facial nerve were identified. At this point, specific attention was directed at the branches that innervate the risorius, levator labii superioris, and zygomaticus major, selecting one that produced commissure excursion solely. Using a nerve stimulator (Aesculap Surgical Instrument, Tuttlingen, Germany), two zygomatic branches moving the oral commissure were identified and transected. The distal stump of the nerve graft was marked with a 5/0 nylon stitch and then tunneled across the midline in a plane above the periosteum of the maxilla and buried in the subcutaneous tissue of the preauricular region of the paralyzed side. Epineural coaptation was then performed between the nerve graft and the selected branches on the normal side using 10/0 nylon sutures.

Second Stage

Once Tinel sign was noted when tapping the paretic side, the second stage was performed. Through a similar approach on

Table 1 Patient demographics and surgical details

Case	Gender	Age (y)	Etiology	Time (mo)	Side	Donor nerve	Recipient nerve	Follow-up (mo)	Synkinesis
1	F	24	Bell	168	Left	2 zygomatic	2 zygomatic	25	Yes
2	F	32	Bell	60	Right	2 zygomatic	Zygomatic trunk	33	No
3	F	31	Ramsay hunt	17	Right	2 zygomatic	Zygomatic trunk	28	No
4	F	38	Bell	20	Left	2 zygomatic	2 zygomatic	23	No
5	F	49	Cholesteatoma	24	Right	2 zygomatic	2 zygomatic	16	No
6	M	16	Congenital	168	Right	2 zygomatic	2 zygomatic	13	No
7	F	34	Bell	36	Left	2 zygomatic	2 zygomatic	17	No
8	M	28	Bell	16	Right	2 zygomatic	2 zygomatic	18	No

Abbreviations: F, female; M, male; mo, months; y, years.

the paretic side, the facial nerve branches were identified at the anterior border of the parotid gland together with the previously tagged nerve graft. Next, the two zygomatic branches were identified using the nerve stimulator (Aesculap Surgical Instrument, Tuttlingen, Germany) and were divided, connecting their distal stump to the nerve graft using 10/0 nylon epineural sutures. In cases in which facial synkinesis were observed preoperatively, the branches responsible of such synkinesis were identified, transected, dissected distally, and connected to the nerve graft as described above.

Results

Etiology of paralysis included Bell palsy, Ramsay Hunt syndrome, cholesteatoma, and one congenital (Dandy–Walker syndrome). Mean age at surgery was 33.8 ± 11.5 years. Time of denervation ranged from 15 to 360 months, with a median of 36 months and a mean of 96.6 ± 109.8 months. One sural nerve graft was used in all cases. The details of the donor and recipient nerves are illustrated in ►**Table 1**. No complications requiring surgery were registered. Follow-up period ranged from 7 to 33 months with a mean of 19 ± 9.7 months. Quantitative assessment using the FACIAL CLIMA showed improvement of both commissural excursion and velocity greater than 75% in four patients, greater than 50% in two patients, and less than 50% in the remaining two patients. Qualitative evaluation revealed a high grade of satisfaction in six patients (75%) (►**Table 2**). The two patients with follow-up of 6 months responded to the questionnaire on the basis of the result obtained so far, assuming that regeneration was still in process (►**Figs. 1** and **2**; ►**Videos 1** and **2**).

Discussion

Incomplete facial paralysis is probably (and most obviously) best defined as any palsy that is not complete, implying that some degree of recovery has occurred following onset of disease. Although it may arise from several conditions, the most frequent causes of incomplete facial paralysis are Bell palsy and herpes zoster infection. Other common causes include congenital, acoustic neurinoma resection, and parotidectomy.[7] Regardless of the etiology, the vast majority of patients with incomplete facial paralysis present with a similar clinical picture characterized by fair symmetry at rest due to the sufficient tone of the facial musculature, various degrees of asymmetry on expression, facial synkinesis secondary to aberrant reinnervation of the target muscles,

Table 2 Quantitative and qualitative outcomes

Case	Recovery (%)		Qualitative assessment		
	CD	CCV	Satisfied	Repeat surgery	Overall grading (0–5)
1	38	27	No	No	2
2	88	85	Yes	Yes	4
3	92	89	Yes	Yes	4
4	82	85	Yes	Yes	4
5	17	11	No	No	1
6	79	76	Yes	Yes	4
7	56	51	Yes	Yes	3
8	62	54	Yes	Yes	4

Abbreviations: CD, commissural displacement; CCV, commissural contraction velocity.
Grading scale: 0, *very poor*; 1, *poor*; 2, *fair*; 3, *good*; 4, *very good*; 5, *excellent*.

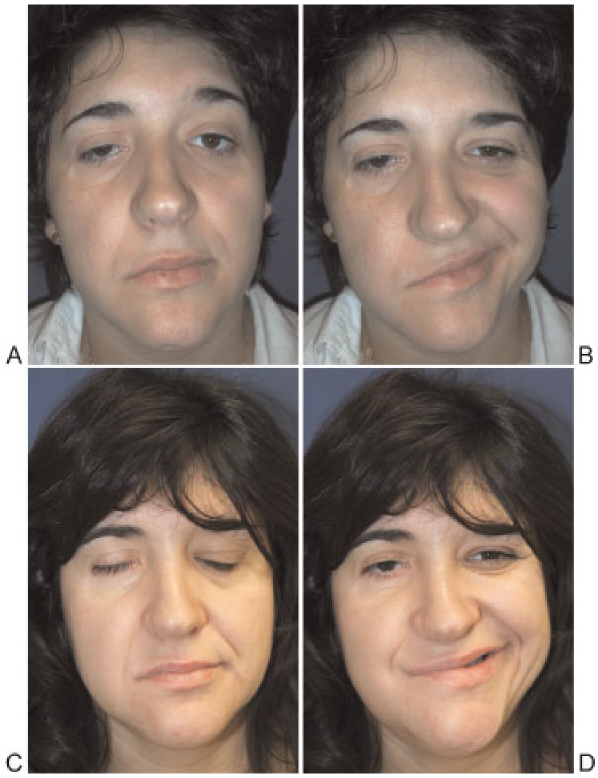

Fig. 1 Case 6: A 32-year-old woman with long standing incomplete right side Bell facial paralysis. Preoperative (A) at rest and (B) smiling. 13 months postoperatively (C) at rest and (D) smiling.

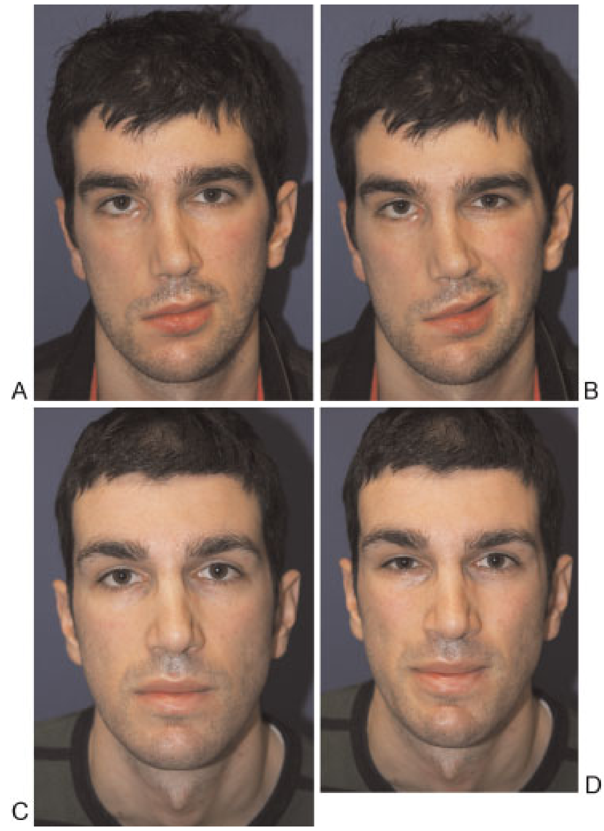

Fig. 2 Case 8: A 28-year-old man with right side Bell palsy. Preoperative (A) at rest and (B) smiling. 18 months postoperatively (C) at rest and (D) smiling.

and hemifacial spasms. Paradoxically, after partial recovery, some of the muscles of facial expression may become hyperactivated producing an unsightly appearance even at rest. Bulstrode and Harrison have described the physical findings of late recovered Bell palsy that include a deep nasolabial fold, blepharospasm, and weakened facial muscles producing frontal asymmetry, reduced function of *depressor anguli oris* and poor commissural excursion.[17] Thus, although most patients with idiopathic paralysis recover, there is still several cases that will need (and seek) reanimation. A recent study on the spontaneous course of Bell palsy, which included 1,701 cases, showed that 29% of patients did not recover completely with 4% of them presenting severe sequela. Moreover, contracture and associated movements were found in 17 and 16% of patients, respectively.[18]

Video 1

Case 2: Postoperative. Online content including video sequences viewable at: www.thieme-connect.com/ejournals/html/doi/10.1055/s-0033-1349347.

Video 2

Case 8: Postoperative. Online content including video sequences viewable at: www.thieme-connect.com/ejournals/html/doi/10.1055/s-0033-1349347.

When reviewing this literature, it is surprising to see that dynamic reanimation of incomplete facial paralysis has not been as thoroughly addressed as its complete counterpart. The smaller number of cases, the coping of patients, and the more extended use of nonsurgical therapies (i.e., botulinum toxin) are probably some of the reasons that explain this. CFNG, nerve transpositions, and free muscle transfer have been reported with varying degrees of success. Irrespective of the technique, most authors agree that the challenge of incomplete facial palsy reanimation lies on restoring what is missing without damaging what has recovered. In this sense, Frey et al advocate performing one-stage CFNG with end-to-side coaptation distally on the recipient nerve of the paralyzed side. The authors report on three cases of long-standing incomplete paralysis reanimated with this technique obtaining good function and symmetry.[6] This initial experience seems promising, however, the real advantages over traditional end-to-end coaptation remain to be investigated. The hypoglossal nerve has also been used as source of neural input for incomplete paralysis. In 2007, Yamamoto et al introduced the neural supercharge concept through a facial–hypoglossal network system, hypothesizing that the remaining potential of the incompletely paralyzed muscles is activated by a neural supercharge effect.[2] However, this technique requires partial sacrifice of the hypoglossal nerve and may produce synkinesis or mass movements when the coaptation is made to the facial nerve trunk even with end-to-side neurorrhaphy.[19] Other authors have reported the use of one stage free muscle transfer with latissimus dorsi minigraft, with significant improvement of symmetry on smile. The authors argue that such approach offers an assured method with which to obtain adequate muscle contraction, suggesting that it may be superior to CFNG[7] with or without muscle transfer, although no formal comparison is conducted. The one-stage concept surely offers an advantage over two-stage procedures and is more straightforward; however, performing a free tissue transfer from the beginning without offering the patient a chance of rehabilitation with "simpler" techniques (i.e., CFNG, nerve transpositions) may seem somewhat aggressive considering the longer operative time and donor site morbidity. In addition, in cases in which an acceptable result is not obtained, the dilemma on whether to try a second free transfer or "go back" and change the approach and perform CFNG can become stressful for both patient and surgeon. Conversely, if CFNG is tried in first instance and the result is not satisfactory, free muscle transfer (neurotized to the already reinnervated nerve graft) can be planned as a step forward of the initial reconstructive approach instead of a step back. In our experience so far, we have obtained good functional and aesthetic results with good symmetry at rest and when smiling, with a high degree of patient satisfaction in 75% of the cases, including two patients whose follow-up is pending but are happy with the result so far as they have greatly improved symmetry at rest and are starting to see some commissural traction. Regarding patients with poor results, one of them (Case 1) had a long time of evolution (i.e., 14 years each) that may partly explain the unsatisfactory outcome. Case 5 presented with a moderate smile asymmetry, with fair commissural excursion on the paralyzed side, and although very little improvement was gained after surgery, her appearance at rest is still balanced and symmetrical, but her asymmetry on smile remains. Subsequently, this patient was treated with botulinum toxin injection for *depressor anguli oris* and a gold weight implant for the upper eyelid.

Regarding the surgical technique and specifically the graft used, for cross-face procedures for either coaptation to facial nerve branches or for neurotization of a free muscle transfer, we routinely use the sural nerve mainly because of its easiness of harvesting, its length, and acceptable donor site morbidity. Before connecting the nerve graft, we perform a meticulous "peel" of the graft removing as much as possible all surrounding connective tissue to ensure a good vascularization of the graft from the surgical bed on the face and upper lip tunnel. Koshima et al have previously described the concept of vascularized nerve graft in one stage for CFNG, using a vascularized lateral femoral cutaneous nerve along with a perforator of the lateral circumflex femoral system, arguing rapid nerve sprouting through the nerve flap and excellent facial reanimation.[20] We do not have experience with this nerve flap technique, although so far we have obtained very good results using nerve grafts. Furthermore, in our opinion, the donor site morbidity in terms of sensory denervation and resultant scar is greater with the lateral femoral cutaneous nerve.

An important issue regarding the management of incomplete facial paralysis is the management of synkinesis which must be considered an integral part of the reanimation surgical plan. Although synkinesis can appear early in the course of regeneration, they are more frequently seen in longstanding disease. When severe, facial synkinesis can seriously impair adequate facial appearance and expression with serious psychological consequences. Treatment options include Botox injections (Allergan, Irvine, CA), selective myectomy, and CFNG, among others. Terzis and Karypidis have recently reported high rates of improvement with a combination of CFNG, Botox, and secondary microcoaptations. However, the conclusions are based on a small sample which is further subdivided into four smaller groups with a variety of techniques.[5] In our series, evident synkinesis were observed in one patient preoperatively that significantly improved after surgery alone. Probably transection of the recipient nerve branches on the paralyzed side and the borrowing of axons from the healthy side contribute to cut the "vicious circle" of synkinesis, reordering the neural inputs of the aberrantly reinnervated facial musculature and thus reducing such involuntary contractions.

Regarding quantitative and qualitative evaluation of outcomes in facial paralysis reanimation, several scales, scores, and optical systems have been developed in an effort to accurately quantify the degree of improvement.[10–13] In our setting, we use the FACIAL CLIMA, described by the senior author in 2008,[14] which allows comparison between patients and also assessment of symmetry with the healthy side individually. Although this system gives information on angles, velocities, and distances of the upper, middle, and lower face, for the purpose of this article, we have evaluated commissural excursion and CCV only, since all patients have undergone dynamic reanimation of the smile. The forehead and lower lip have not been addressed because they were not treated uniformly in all patients and only static procedures were performed. Also, it must be noted that the FACIAL CLIMA gives absolute values, namely excursion in mm and velocity in mm/s. However, to have more accurate information on improvement, each patient's record is transformed into a percentage of recovery considering his or her healthy side as the reference. With this, we avoid bias from variations that may occur between patients with different smiles.

In conclusion, incomplete facial paralysis reanimation may sometimes become more challenging than the complete scenario due to the need of restoring motion without deteriorating the remaining/recovered part. In addition, these patients often present with synkinesis which should be considered an integral part of the surgical strategy. Although different techniques have been described, CFNG remains to be a very valuable tool of reanimation, as not only good functional and aesthetic results are obtained, but synkinesis can also be effectively addressed. Correct patient selection, establishing realistic expectations of recovery, and informing on the possibility of having to go a step further on the reconstructive plan (i.e., free muscle transfer) are important factors to consider when planning reanimation with this technique.

The main disadvantages include the need of a two-stage procedure and the variability of outcomes that is sometimes seen even for a single surgeon.[21] Notwithstanding such shortcomings, considering the results obtained so far, CFNG has become the technique of choice for smile rehabilitation of patients with incomplete facial paralysis in our institution.

References

1 Gilden DH. Clinical practice. Bell's Palsy. N Engl J Med 2004;351 (13):1323–1331

2 Yamamoto Y, Sekido M, Furukawa H, Oyama A, Tsutsumida A, Sasaki S. Surgical rehabilitation of reversible facial palsy: facial—hypoglossal network system based on neural signal augmentation/neural supercharge concept. J Plast Reconstr Aesthet Surg 2007;60(3):223–231

3 Furukawa H, Saito A, Mol W, Sekido M, Sasaki S, Yamamoto Y. Double innervation occurs in the facial mimetic muscles after facial-hypoglossal end-to-side neural repair: rat model for neural supercharge concept. J Plast Reconstr Aesthet Surg 2008;61 (3):257–264

4 Terzis JK, Wang W, Zhao Y. Effect of axonal load on the functional and aesthetic outcomes of the cross-facial nerve graft procedure for facial reanimation. Plast Reconstr Surg 2009;124(5):1499–1512

5 Terzis JK, Karypidis D. Therapeutic strategies in post-facial paralysis synkinesis in adult patients. Plast Reconstr Surg 2012;129 (6):925e–939e

6 Frey M, Giovanoli P, Michaelidou M. Functional upgrading of partially recovered facial palsy by cross-face nerve grafting with distal end-to-side neurorrhaphy. Plast Reconstr Surg 2006;117(2):597–608

7 Takushima A, Harii K, Okazaki M, Ohura N, Asato H. Availability of latissimus dorsi minigraft in smile reconstruction for incomplete facial paralysis: quantitative assessment based on the optical flow method. Plast Reconstr Surg 2009;123(4):1198–1208

8 Scaramella LF, Tobias E. Facial nerve anastomosis. Laryngoscope 1973;83(11):1834–1840

9 Anderl H. Cross-face nerve transplant. Clin Plast Surg 1979;6 (3):433–449

10 House JW, Brackmann DE. Facial nerve grading system. Otolaryngol Head Neck Surg 1985;93(2):146–147

11 Linstrom CJ, Silverman CA, Susman WM. Facial-motion analysis with a video and computer system: a preliminary report. Am J Otol 2000;21(1):123–129

12 Sargent EW, Fadhli OA, Cohen RS. Measurement of facial movement with computer software. Arch Otolaryngol Head Neck Surg 1998;124(3):313–318

13 Meier-Gallati V, Scriba H, Fisch U. Objective scaling of facial nerve function based on area analysis (OSCAR). Otolaryngol Head Neck Surg 1998;118(4):545–550

14 Hontanilla B, Aubá C. Automatic three-dimensional quantitative analysis for evaluation of facial movement. J Plast Reconstr Aesthet Surg 2008;61(1):18–30

15 Hontanilla B, Vila A. Comparison of hemihypoglossal-facial nerve transposition with a cross-facial nerve graft and muscle transplant for the rehabilitation of facial paralysis using the facial clima method. J Plast Surg Hand Surg 2012;46(1):25–31

16 Hontanilla B, Marré D. Comparison of hemihypoglossal nerve versus masseteric nerve transpositions in the rehabilitation of short-term facial paralysis using the Facial Clima evaluating system. Plast Reconstr Surg 2012;130(5):662e–672e

17 Bulstrode NW, Harrison DH. The phenomenon of the late recovered Bell's palsy: treatment options to improve facial symmetry. Plast Reconstr Surg 2005;115(6):1466–1471

18 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

19 Furukawa H, Saito A, Mol W, Sekido M, Sasaki S, Yamamoto Y. Double innervation occurs in the facial mimetic muscles after facial-hypoglossal end-to-side neural repair: rat model for neural supercharge concept. J Plast Reconstr Aesthet Surg 2008;61(3): 257–264

20 Koshima I, Nanba Y, Tsutsui T, Takahashi Y, Itoh S. New one-stage nerve pedicle grafting technique using the great auricular nerve for reconstruction of facial nerve defects. J Reconstr Microsurg 2004;20(5):357–361

21 Lee EI, Hurvitz KA, Evans GR, Wirth GA. Cross-facial nerve graft: past and present. J Plast Reconstr Aesthet Surg 2008;61(3): 250–256