The "Babysitter" Procedure: Minihypoglossal to Facial Nerve Transfer and Cross-Facial Nerve Grafting

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Background: In 1984, Terzis introduced the "babysitter" procedure, a new concept in facial reanimation. It involves two stages, with coaptation of ipsilateral 40 percent hypoglossal to facial nerve on the affected side, performed concomitantly with cross-facial nerve grafting and secondary microcoaptations 8 to 15 months later. This article presents the senior author's (J.K.T.) experience with the original procedure.

Methods: Of 75 patients who had minihypoglossal nerve transfer, 20 fulfilled the selection criteria for the original babysitter procedure. All patients' records, photographs, videotapes, and needle electromyography studies were reviewed. The clinical results were scored using Terzis' Grading Scale. Eye closure, smile, and lower lip depression were each assessed separately. Functional and aesthetic outcomes and preoperative and postoperative electromyography results were analyzed.

Results: Seventy-five percent of patients achieved excellent and good results, 15 percent had moderate results, and 10 percent had fair results. The difference between preoperative and postoperative eye closure was statistically significant (t test, $p < 0.001$). Symmetrical smile and full contraction (excellent result) was achieved in two patients (10 percent), 13 patients (65 percent) had nearly symmetrical smile (good result), and five patients (25 percent) had a moderate result. Two patients (10 percent) had full lower lip depression (excellent result) and 15 (75 percent) had good results. In three patients (15 percent), subsequent digastric or platysma muscle transfer was performed because of inadequate depression and symmetry (moderate result). A statistically significant difference was observed between preoperative and postoperative electromyography results, in eye closure, smile, and lower lip depression.

Conclusions: The original babysitter procedure offers significant improvement in selected patients with facial paralysis. Symmetry and coordinated movements can be restored, with satisfying aesthetic and functional outcomes. (*Plast. Reconstr. Surg.* 123: 865, 2009.)

The aim of facial reanimation surgery is to achieve facial symmetry at rest, and during voluntary and emotional animation. Synchronized and coordinated facial expression is the important functional and aesthetic goal.

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When the proximal part of the facial nerve is unusable, different motor donor nerves can be used (accessory,[1] hypoglossal,[2–6] trigeminal,[7,8] and phrenic[9,10]), with potential loss of function at the donor side and production of uncoordinated mass facial movements, sometimes exaggerated and disproportionate to the unaffected side and with absence of spontaneous emotional expression.

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The technique of cross-facial nerve grafting in the early 1970s, as a method of importing motor axons from the normal to affected side,[11–17] was a major breakthrough for coordinated animation and emotional expression. The contralateral facial nerve nucleus serves as the source of signals (pacemaker) carried through cross-facial nerve grafting to the affected side. Although an ingenious concept, shortcomings such as long distances for regenerating axons to elongate and prolonged denervation period could be detrimental, leading to irreversible muscle atrophy, unless the procedure occurs within 6 months from the onset of facial paralysis.

To overcome these disadvantages, Terzis[18–20] introduced the babysitter procedure in 1984, which uses a portion of an ipsilateral powerful motor donor nerve (hypoglossal) to rapidly innervate the paretic musculature, whereas cross-facial nerve grafting regenerates across the face. The procedure involves two stages. In the first stage, 40 percent of the ipsilateral hypoglossal (minihypoglossal) nerve is coapted to the denervated facial nerve trunk, and three or four cross-facial nerve grafts are placed across the face. The minihypoglossal nerve promptly provides regenerating motor fibers to the facial nerve that quickly reach the affected facial muscles. At the second stage, 8 to 12 months later, the distal end of the cross-facial nerve grafts are connected to selected distal branches of the affected facial nerve, whereas the minihypoglossal to facial nerve coaptation remains undisturbed. This is the original "babysitter" procedure, and variations have been reported since its inception.[21,22] In late cases, if after the first stage, the functional results are considered inadequate, a local or free muscle can be transferred to the paretic side to augment facial reanimation. This, however, is not an integral part of the original babysitter procedure.

PATIENTS AND METHODS

Inclusion Criteria

Preoperatively, extensive needle electromyographic studies take place. The presence of fibrillations signifies "present" facial musculature despite denervation, and the babysitter procedure can be performed. Silent preoperative needle electromyography of the facial muscles signals atrophic musculature replaced by scar and is a contraindication for the babysitter procedure. In late cases, more than 2 years after tumor extirpation, if the facial nerve has remained in-continuity, despite total clinical facial paralysis, needle electromyographic studies may show fibrillations. This finding makes the patient suitable for the babysitter procedure. Once the patient is selected, the first stage takes place at the earliest.

At 6 months after stage I, the patient is reevaluated clinically and electrophysiologically. If tongue thrusting against the teeth produces strong facial muscle contractions, the second stage with microcoaptations of the cross-facial nerve grafts is performed. If there is no clinical evidence of contractions, or the resulting animation on the paretic side is inadequate, importation of additional muscle is considered for the second stage.

Patient Demographics

From January of 1984 to December of 2003, the minihypoglossal nerve was used in 75 patients. Twenty patients had the original babysitter procedure. The rest had either importation of additional muscle transfer or coaptation of the minihypoglossal nerve to the cervicofacial division.

There were 12 female and eight male patients, with ages ranged from 5 to 53 years (mean, 29 years). Four were younger than 20 years, 11 were between 20 and 40 years, and five were older than 40 years. The follow-up period varied from 2 to 20 years (mean, 4.5 years).

The origin of the paralysis was central and intratemporal (mostly acoustic neuroma) tumor resection in 10 patients, trauma in six patients, removal of intracranial vascular malformation in three patients, and Bell's palsy in one patient. The denervation period varied from 6 to 24 months (mean, 14 months) in 14 patients (70 percent) with complete facial palsy, and from 25 to 60 months (mean, 47 months) in six patients (30 percent) with fibrillations on needle electromyography.

In nine patients (45 percent), the facial nerve was coapted directly end-to-side with the ipsilateral hypoglossal nerve (after 40 percent neurectomy of the latter) (Figs. 7, *above, right,* and 8, *above, left*), in seven (35 percent), the facial nerve was coapted directly end-to-end with a longitudinal segment of the hypoglossal nerve (after longitudinal split of 40 percent of the latter) and in four patients (20 percent) interpositional nerve grafts were used in end-to-side fashion.

Surgery

Minihypoglossal to Facial Nerve Transfer

The hypoglossal and affected facial nerves are accessed by means of a curved inframandibular incision approximately 4 cm long. After retraction of the posterior belly of the digastric muscle, the hypoglossal nerve is exposed.

Under the operating microscope, 40 percent of the hypoglossal nerve cross-section is severed. The facial nerve is mobilized and, if possible, an end-to-side coaptation takes place at the neurectomy site of the hypoglossal nerve (Figs. 1, 7, *above, right*, and 8, *above, left*). Otherwise, 40 percent of the proximal hypoglossal nerve is split longitudinally with a diamond knife for several centimeters and brought superolaterally for end-to-end coaptation with the facial nerve. In four patients, two short sural nerve grafts were used to connect the main trunk of facial nerve with the partially neurectomized hypoglossal nerve (end-to-side).

Cross-Facial Nerve Graft

Through a modified face-lift incision, the contralateral unaffected facial nerve is explored, all distal branches are microstimulated, and the entire extratemporal facial nerve is mapped. Selected motor donor branches are then coapted to corresponding sural nerve grafts. Eleven patients had four, eight patients had three, and one patient had two cross-facial nerve grafts (Figs. 7, *above, right* and 8, *above, left*).

Typically, one cross-facial nerve graft destined to provide innervation to the affected eye sphincter is coapted to a selected upper zygomatic branch that innervates the normal eye sphincter, tunneled across the upper lip close to nostrils, and brought with a tiny stab wound to the superior border of the contralateral ear. A second cross-facial nerve graft destined for smile restoration is coapted to the main zygomatic branch on the normal side and tunneled through the lower lip close to the mental groove up to the pretragal area. A third cross-facial nerve graft is coapted to a selected buccal branch and tunneled along the submental area up to the earlobe. The fourth cross-facial nerve graft for lower lip depression is coapted to a selected mandibular branch, passed along the cervicomental angle, and brought below the earlobe. The donor nerve branches should be similar to the recipient ones for coordinated movements to take place.

Depending on the advancing Tinel's sign and electromyographic findings, the second stage takes place 6 to 8 months later (mean, 12 months). Through a modified face-lift incision, the distal branches of the affected facial nerve are explored at the anterior border of the parotid gland. Using microstimulation, the branches that responded the best are selected for coaptation with the respective cross-facial nerve graft. The minihypoglossal to facial nerve coaptation is left intact (Fig. 8, *above, right*).

Postoperative Rehabilitation

Each patient follows an exercise regimen in front of a mirror. For recruitment of the contralateral facial nerve, they smile, first on the normal and then on the affected side (Fig. 10, *above*). For recruitment of the minihypoglossal nerve, they push the tongue against the front teeth when they smile. They also use a slow pulse stimulator (Slo-Pulse Muscle Stimulator) applied so as to "bracket" the long axis of the target muscles (lip levators, lip depressors) for 20 minutes, five times per day. The proximal electrode is placed over the

Fig. 1. Cadaveric dissection showing the main trunk of the facial nerve trunk (*arrow*) being mobilized and coapted by end-to-side coaptation with the hypoglossal nerve. The posterior belly of the digastric muscle has been reflected superiorly. *VII*, facial nerve; *XII*, hypoglossal nerve.

zygomatic arch and the distal electrode is placed over the lower lip depressors. The settings vary according to the status of muscle innervation and the needle electromyographic findings. The greater the denervation, the longer the pulse width required to generate a contraction. The width varies from 10 to 300 msec. The ramp (approximately 3) and pulse rate (usually three stimuli every 10 seconds) are set during the patient's visit.

The status of nerve regeneration and muscle reinnervation is determined by clinical examination and needle electromyography. The results of electromyography at the first office visit, 6 months after the first stage of the babysitter procedure and at 1 year after the second stage, were analyzed. The results of needle electromyography (volitional effort expressed in evoked potentials) were rated from 0 to 3 (Table 1). Clinical photographs and standardized video recordings are taken preoperatively and postoperatively documenting eye closure, blink reflex, lip elevation, lip retraction, dental show, smile, and lower lip depression. These were viewed separately by three independent evaluators who had not participated in any operative procedure. The scoring systems used for the functional and aesthetic assessment are shown in Tables 2 through 4). Approval for the study was given by the Eastern Virginia Medical School Institutional Review Board (no. 06-12-XX-0351).

Statistical Analysis

The outcome variables were defined as the electromyography score and evaluators' score before and after surgery. The data were obtained averaged across the three evaluators. Descriptive statistics including mean, standard deviation, and percentage were used to analyze the data. Spearman's correlation coefficient was used to test the association between different demographic or clinical parameters (e.g., age, denervation time) and final outcomes. Paired t tests (and the Wilcoxon signed rank test) were used to compare electromyographic and functional and aesthetic readings before and after surgery. SPSS version 12.0 (SPSS, Inc., Chicago, Ill.) was used and the significance level was set at 0.05.

Table 1. Grading for the Electromyography Studies (Volitional Effort)

No. of Motor Unit Potentials	Electrogenesis
0	No evoked potentials (–)
1	Some evoked potentials (+/–)
2	Moderate evoked potentials (incomplete interference pattern) (++)
3	Full electrogenesis (complete interference pattern) (+++)

Table 2. Terzis' Grading for Assessment of Eye Closure

Grade	Description
1	No eye closure
2	Poor eye closure
3	Incomplete eye closure
4	Nearly complete eye closure
5	Complete eye closure

Table 3. Terzis' Functional and Aesthetic Grading System Used

Group	Grade	Description	Result
I	1	Deformity, no contraction	Poor
II	2	No symmetry, minimal contraction	Fair
III	3	Moderate symmetry and contraction	Moderate
IV	4	Symmetry, nearly full contraction	Good
V	5	Symmetrical smile with full contraction	Excellent

Table 4. Terzis' Grading for Assessment of Lip Depressors

Grade	Description
0	Total paralysis
0.5	Trace contraction, no movement
1	Observable movement but no symmetry
1.5	Almost complete excursion of lower lip
2	Normal symmetrical movement of lower lip

RESULTS

Electromyographic Outcomes

Orbicularis Oculi Muscle

Improvement was noted in the volitional effort with appearance of incomplete and complete interference patterns. The dual innervation of the affected facial musculature by the ipsilateral minihypoglossal and contralateral facial nerve was evidenced in the electromyography studies (Fig. 2). The minihypoglossal produced higher volitional effort as compared with signals carried through the cross-facial nerve grafts in all muscles that received dual innervation. The volitional effort of the orbicularis oculi muscle was significantly different (t test, $p < 0.001$) between preoperative electromyography and that at 1 year postoperatively.

Lip Levators and Commissure Retractors

The difference in the electromyographic responses at the first office visit and at 1 year post-

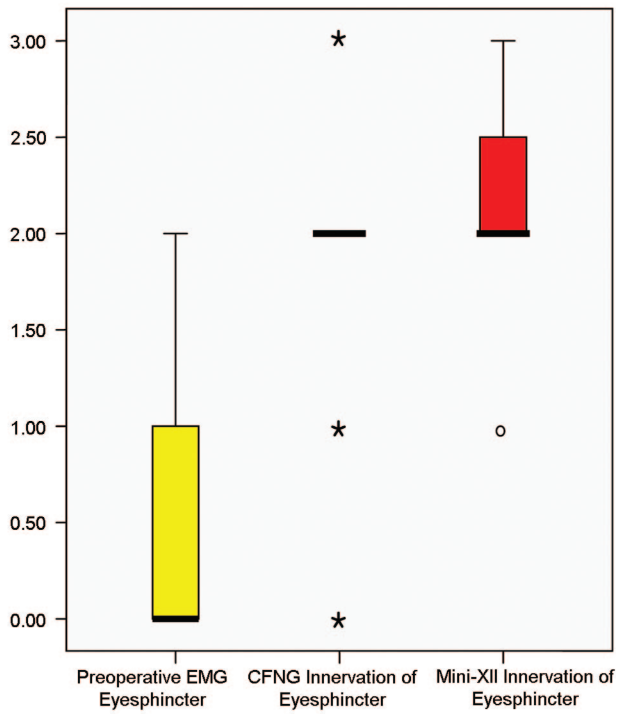

Fig. 2. Grading from needle electromyography of the eye sphincter preoperatively and postoperatively (after identifiable separate innervation from the cross-facial nerve grafts and mini-hypoglossal nerve). The *dark line* is the median value, outliers are marked by the asterisks and small circle. The difference of the ends of the whiskers is the range. The end of the box is the interquartile range.

operatively was statistically significant ($p < 0.001$; mean, 1.481). Excellent motor unit activity was observed in all patients.

Lip Depressor

The lip depressors produced the largest difference between preoperative and postoperative electrophysiologic responses ($p < 0.001$), with a mean value of 1.731.

Tongue Innervation

Electrophysiologic studies of the tongue were performed to ensure that the hypoglossal nerve was intact preoperatively and to document any postoperative loss of tongue innervation. In all cases, the final electromyographic studies showed full electrogenesis on the ipsilateral side of the tongue. Occasionally, at 6-month follow-up, there were some fibrillations on the ipsilateral side of the tongue, but these disappeared by 9 to 12 months. No patient developed hemitongue atrophy, nor was there any observable or measurable intraoral deficit.

Clinical Outcomes

Eye Closure

Significant improvement was noted in eye closure (Fig. 7). For further optimization, four patients needed minor operations to correct the remaining scleral show with lower eyelid suspension with mini tendon grafts, or eye springs. These procedures were undertaken 14 to 20 months after the babysitter procedure. The difference in the preoperative and 1-year postoperative eye closure was statistically significant (t test, $p < 0.001$) (Fig. 3).

Smile

A symmetrical smile was the cornerstone of an excellent result (Figs. 8 through 10). According to the clinical assessment (Table 3), all patients demonstrated improvement postoperatively (Fig. 4).

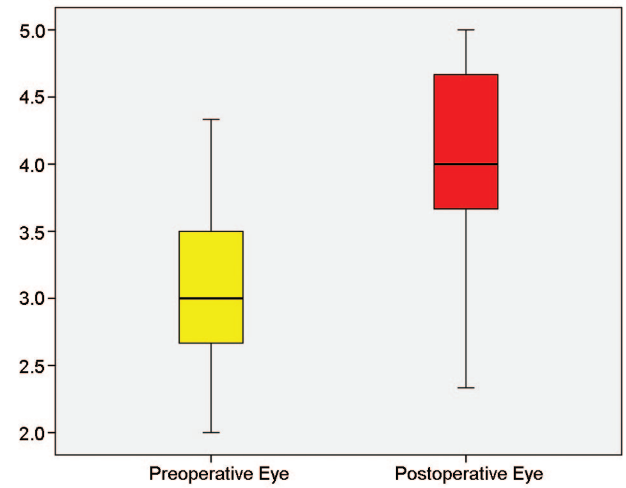

Fig. 3. Functional grading of the eye sphincter preoperatively and postoperatively.

Fig. 4. Functional grading of the smile preoperatively and postoperatively (two patients were outliers on the first box plot).

Two patients (10 percent) achieved symmetrical smile and full contraction (excellent result), 13 (65 percent) had nearly symmetrical smile with nearly full contraction (good result), and five patients (25 percent) had moderate symmetry with moderate contraction (moderate result). The functional scores for eye closure, smile, and lip depression were all positively correlated to the presence of evoked potentials on electromyography. The correlation was stronger for the production of the smile ($p < 0.006$).

Lower Lip Depression

Two patients (10 percent) had full denture smile (excellent result) (Fig. 5). Fifteen patients (75 percent) had nearly complete excursion of the lower lip and almost full denture smile (good result). Three patients (15 percent) had observable movement but inadequate excursion and symmetry (moderate result). At 13 months after the babysitter procedure, two patients (10 percent) had transfer of the anterior belly of the digastric muscle to the lower lip depressors and one patient (5 percent) had ipsilateral platysma transfer. The nerve to the anterior belly of the digastric muscle was coapted to the cross-facial nerve graft, which carried fibers from the contralateral marginal mandibular branch.

Overall Outcome

The results were graded from poor to excellent (Table 3). During voluntary and emotional expression, one patient (5 percent) achieved excellent symmetry, 14 (70 percent) had good symmetry, and three (15 percent) had moderate symmetry; in two patients (10 percent), the facial symmetry was considered inadequate (Fig. 6). The postoperative score was higher for all patients. The Wilcoxon signed rank test showed that postoperative clinical outcomes were significantly higher ($p < 0.001$).

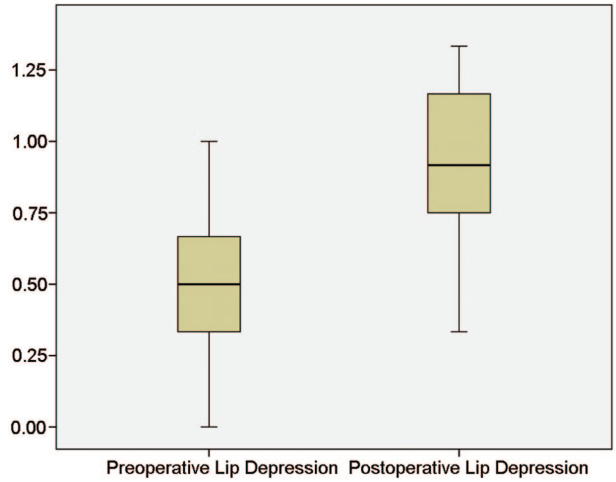

Fig. 5. Functional grading of the lower lip depressors preoperatively and postoperatively.

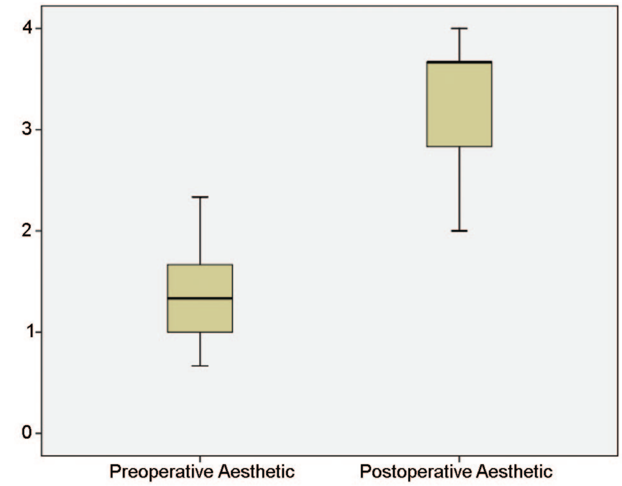

Fig. 6. Preoperative and postoperative grading of the patients' functional and aesthetic outcome.

All patients achieved a degree of emotional and coordinated movement. Younger patients (younger than 20 years) instinctively developed synchronous facial movements with no need for motor reeducation. Patients aged 20 to 35 years learned to animate the affected side within 3 months of intensive training and easily exhibited coordinated voluntary and involuntary animation. In older patients, postoperative rehabilitation spanned longer periods.

The four patients with interposition nerve grafts (two coaptation sites) had no statistically significant difference in the functional and aesthetic outcomes compared with those who had direct minihypoglossal to facial nerve coaptation. The small number of these patients may have influenced the statistical results.

The mean age of the patients was 29 years, the majority were in their third decade, five were younger than 20 years, and three were older than 40 years. As a result, there was no significant difference among the different age groups with regard to the electromyographic changes or the functional and aesthetic results.

The denervation time played a role in the preoperative and postoperative change of the lower lip depression. Patients with less than 2 years of denervation achieved better results when compared with ones with longer denervation ($p < 0.007$). However, the denervation time did not seem to influence the postoperative electromyographic changes or the functional outcome of the eye sphincter and lip levators. This possibly relates to the fact that all patients with prolonged denervation time had fibrilla-

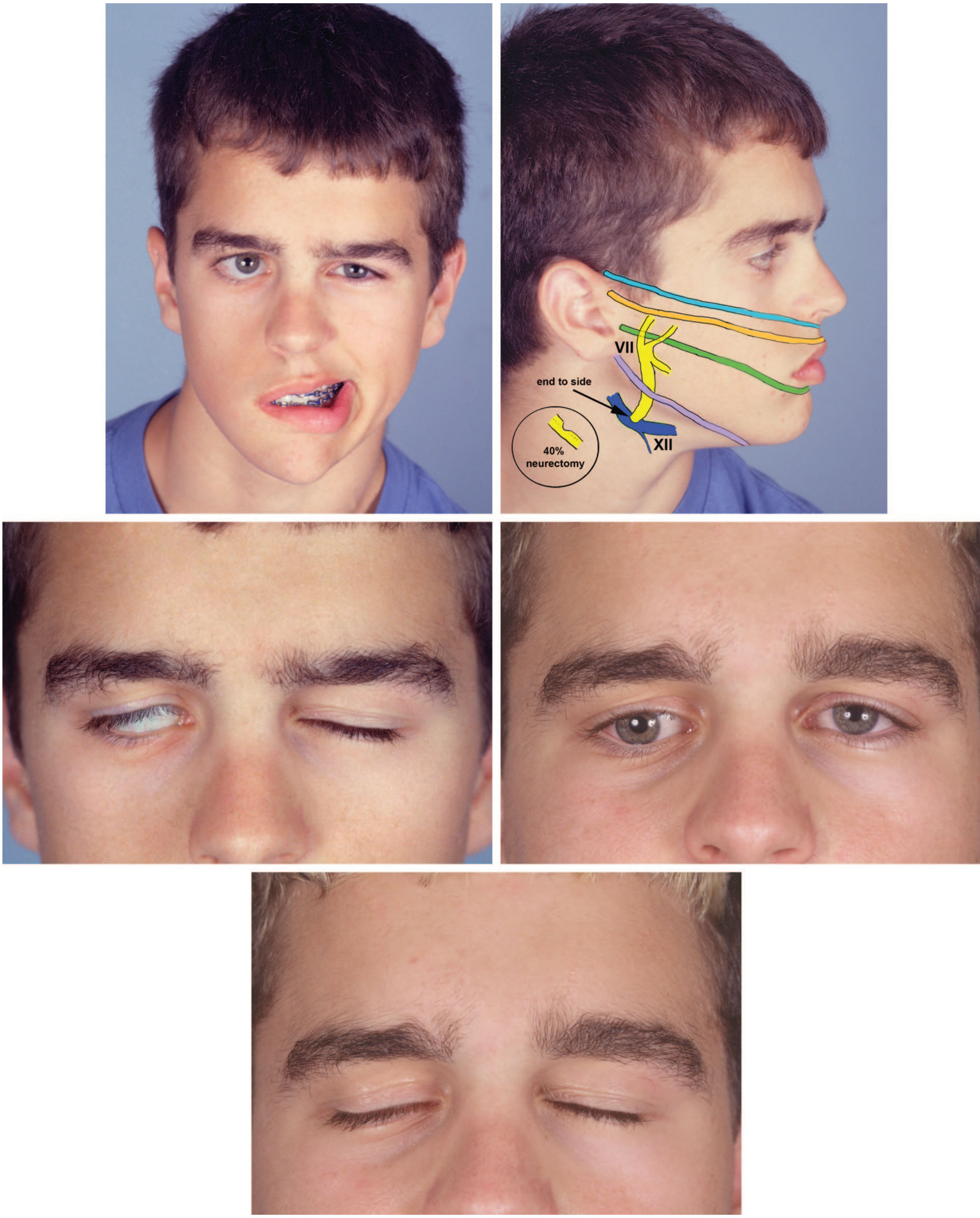

Fig. 7. A 16-year-old male patient developed global right-sided facial paralysis following excision of astrocytoma of the fourth ventricle (*above*, *left*). Cranial nerves IV and VI were also involved and he had poor eye closure (*center, left*). Twenty months after the injury, he had the babysitter procedure and placement of four cross-facial nerve grafts with end-to-side coaptation of the ipsilateral facial nerve trunk to the hypoglossal nerve (*above, right*). Thirteen months later, he had stage II of the babysitter procedure, which involved microcoaptations of the cross-facial nerve grafts to selected zygomatic, buccal, and marginal mandibular branches of the affected facial nerve. Postoperatively, at 1 year, he regained complete eye closure (*center*, *right* and *below*). The overall functional result was rated as poor preoperatively and excellent postoperatively.

tions on preoperative electromyography. Examples of the babysitter procedure are depicted in Figures 7 through 10.

DISCUSSION

Körte[2] introduced and Conley and Baker[4] and Conley and May[23] popularized hypoglossal to facial nerve transfer for facial paralysis when the proximal facial nerve trunk is not usable and the facial muscles are still available.[4,6,24] The downside included hemiglossal atrophy resulting from sacrifice of the entire hypoglossal nerve, and difficulties with speech, mastication, and swallowing, especially when other cranial nerves (glossopha-

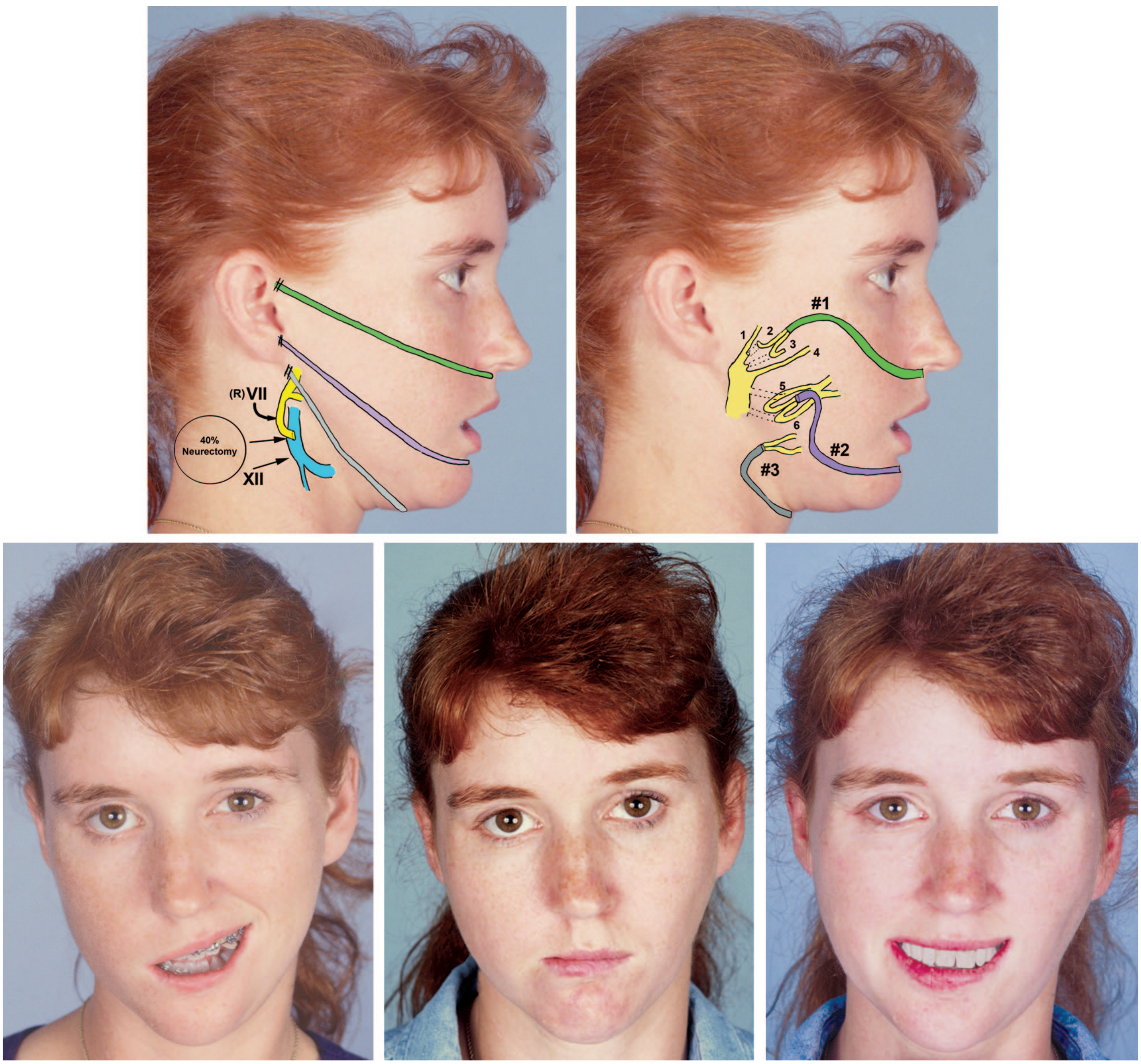

Fig. 8. A 28-year-old woman was involved in a motorcycle accident and suffered right temporal bone fracture with facial nerve injury. She presented to our center with complete right-sided facial paralysis (*below*, *left*). At 6 months after injury, she underwent the babysitter procedure with three cross-facial nerve grafts and end-to-side coaptation of the facial nerve trunk to the ipsilateral hypoglossal nerve (*above*, *left*, stage I of the babysitter procedure). Eight and one-half months later, she had secondary microcoaptations of the cross-facial nerve grafts to the upper zygomatic, main zygomatic, and buccal branches of the right facial nerve (*above*, *right*, stage II of the babysitter procedure). In addition, the patient had a mini-tendon graft to the right lower eyelid. Her functional and aesthetic appearance was rated as poor preoperatively and excellent postoperatively. Postoperative photographs obtained 6 months after the babysitter procedure demonstrated symmetrical smile with full contraction and dental show, and her overall functional and aesthetic result was rated as excellent (*below*, *center* and *below*, *right*).

Fig. 9. A 27-year-old woman developed complete right-sided facial paralysis following removal of an acoustic neuroma. The intraoperative findings showed that it was a 4 × 3-cm tumor that was completely removed, but the facial nerve—despite the severe compression—was left in continuity. She presented to our center 10 months after the onset of facial paralysis (*above*). However, soon afterward, she became pregnant and the surgery was postponed. At 2 years 3 months (27 months) of denervation time, she underwent the babysitter procedure with three cross-facial nerve grafts and direct coaptation of the main trunk of the facial nerve to the ipsilateral minihypoglossal nerve. At the second stage, 15 months later, secondary microcoaptations took place between the cross-facial nerve grafts and selected upper zygomatic, main zygomatic, and buccal mandibular branches of the affected facial nerve. No other operations were performed. Her overall functional and aesthetic appearance was rated as poor preoperatively and excellent postoperatively. (*Below*) Postoperative photographs obtained 1 year after the babysitter procedure, showing the face in repose and with restoration of a symmetrical smile.

Fig. 10. Same patient as shown in Figure 9. She was also capable of an independent smile (i.e., contracting the paretic side and/or normal side independently) (*above*). The patient has synchronous, dynamic, and coordinated animation. Her excellent result was maintained for the 18 years of follow-up (*below*).

ryngeal) are involved.[10,25,26] In addition, the hypoglossal nerve transfer resulted in movements uncoordinated with the contralateral side. In comparison, cross-facial nerve grafting provides synchronized, coordinated movements,[11–17] although the long interval for reinnervation could result in further atrophy and fibrosis of the denervated muscles. Furthermore, the two suture lines inevitably lead to additional axonal loss.[27]

Combining the benefits and addressing the problems of the two techniques Terzis[18–20] introduced in 1984, the babysitter procedure, which involves the use of 40 percent of the ipsilateral hypoglossal nerve (to salvage the facial musculature from denervation atrophy) in conjunction with cross-facial nerve grafting. Work by Kalantarian et al.[19] showed that 40 percent of the hypoglossal nerve can be safely harvested without causing tongue atrophy and can provide adequate motor innervation to the severed facial nerve. Miehlke and Stennert[28] used a combination of the entire hypoglossal nerve and a single cross-facial nerve graft to achieve facial reanimation.

Instead of longitudinal splitting of the hypoglossal nerve, neurectomy of 30 to 40 percent can take place with subsequent hypoglossal to facial nerve end-to-side coaptation.[29–32] May[33,34] visited Terzis in Norfolk and adopted the idea of the partial hypoglossal to facial nerve transfer by using an interposition jump graft, a technique practiced by Terzis, who demonstrated the benefits from experimental end-to-side neurorrhaphies.[30] Partial neurectomy with severance of the perineurium produced the most optimal results. This explains the findings by Koh et al.,[35] who reported poor results after using nerve grafts with no severance of the epineurium in hypoglossal to facial nerve end-to-side nerve coaptation. Atlas and Lowinger[36] recommended beveled partial incision of the hypoglossal nerve and end-to-side coaptation with the mobilized intratemporal portion of the facial nerve.

Although the best timing for using the minihypoglossal nerve is within 2 years after denervation, satisfactory results were produced in cases with longer denervation time, provided that the facial nerve was in-continuity. Conley[37] and others[38] have reported satisfactory results with hypoglossal to facial nerve transfer even after 4 years after injury, if the facial nerve was in-continuity.

Cooper et al.[39] looked at the motion of the normal hemiface after Miehlke and Stennert[28] used a combination of the entire hypoglossal nerve and a single cross-facial nerve graft to achieve facial reanimation. They concluded that there was no permanent deficit when careful choice of branches takes place. In our series, most of the patients had three or four cross-facial nerve grafts. The donor branches were carefully selected by means of microstimulation and intraoperative mapping of distal muscle targets on all patients. None of them developed deficit in facial mobility on the normal side.

The strategy behind the babysitter procedure is that the minihypoglossal nerve is used to salvage the paretic facial musculature, but not for reanimation. The contralateral facial nerve “paces” and “synchronizes” the facial expression. With time, the brain learns to incorporate these movements, which become spontaneous.[40] In children, the process is very short, but in older patients it requires intensive rehabilitation to dissociate tongue movements from facial ones. As the minihypoglossal to facial nerve coaptation is not severed, the duplicity of innervation is maintained. Thus, the patient activates only contralateral facial nerve fibers while speaking or during involuntary expression, but when asked to push the tongue against the teeth, the entire hemiface contracts. However, this pathway (minihypoglossal to facial nerve transfer) remains dormant during daily communication. Manktelow et al.[7] reported the possibility of acquiring coordinated smile following free muscle transfers innervated by the masseter nerve, which they attributed to cerebral adaptation. Several studies have indicated that the central nervous system is capable of modifying its organization (cerebral plasticity), leading to functional changes.[40–43]

Endo et al.[21] validated the babysitter procedure as valuable in creating a near-natural smile. Using only one cross-facial nerve graft, they were able to distinguish electromyographically the dual innervation provided by the ipsilateral crossover nerve and the contralateral facial nerve. They also suggested that the high voltage and full interference pattern following stimulation of the “babysitters” indicated superior innervation over the cross-facial nerve grafts.

CONCLUSIONS

The babysitter procedure combines the benefit of two techniques: provision of a powerful ipsilateral motor donor, the hypoglossal nerve, which very quickly restores the bulk to the denervated facial musculature; and the cross-facial nerve grafts, which provide synchronized, physiologic facial movements and emotional expression. Extremely rewarding results can be achieved in voluntary and involuntary animation, provided the patients are properly selected, well motivated, and compliant with postoperative rehabilitation.

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REFERENCES

1. Drobnik E. Über die Behandlung der Kinderlähmung mit Funktionsheilung und Funktionsübetragung der Muskeln. *Dtsch Z Chir.* 1896;43:473.

2. Körte W. Ein Fall von Nervenpfropfung des Nervus facialis auf den Nervus hypoglossus. *Dtsch Med Wochenschr.* 1903;29:293.
3. Gavron JP, Clemis JD. Hypoglossal-facial nerve anastomosis: A review of forty cases caused by facial nerve injuries in the posterior fossa. *Laryngoscope* 1984;94:1447–1450.
4. Conley J, Baker DC. Hypoglossal-facial nerve anastomosis for reinnervation of the paralyzed face. *Plast Reconstr Surg.* 1979; 63:63–72.
5. Stennert EI. Hypoglossal facial anastomosis: Its significance for modern facial surgery. II. Combined approach in extratemporal facial nerve reconstruction. *Clin Plast Surg.* 1979; 6:471–486.
6. Pitty LF, Tator CIL. Hypoglossal-facial nerve anastomosis for facial nerve palsy following surgery for cerebellopontine angle tumors. *J Neurosurg.* 1992;77:724–731.
7. 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;118:885–899.
8. Terzis JK, Noah EM. Möbius and Möbius-like patients: Etiology, diagnosis, and treatment options. *Clin Plast Surg.* 2002; 29:497–514.
9. Lee KK, Terzis JK. Management of acute extratemporal facial nerve palsy. *Clin Plast Surg.* 1984;11:203–210.
10. Baker DC. Facial paralysis. In: McCarthy JG, ed. *Plastic Surgery.* Vol. 3. Philadelphia: Saunders; 1990:2237.
11. Scaramella LF. Preliminary report on facial nerve anastomosis. In: *Proceedings of the 2nd International Symposium on Facial Nerve Surgery*, Osaka, Japan, 1970.
12. Terzis JK, Noah ME. Analysis of 100 cases of free-muscle transplantation for facial paralysis. *Plast Reconstr Surg.* 1997; 99:1905–1921.
13. Scaramella L. L'anastomosi tra i due nervi facciali. *Arch Otol.* 1971;82:209.
14. Smith JW. A new technique of facial animation. In: *Transactions of the 5th International Congress of Plastic and Reconstructive Surgery*, Chadswick, New South Wales, Australia, 1971. London: Butterworths; 1971.
15. Anderl H. Reconstruction of the face through cross-face nerve transplantation in facial paralysis. *Chir Plast.* 1973;2:17.
16. Anderl H. Cross-face nerve grafting: Up to 12 months of seventh nerve disruption. In: Rubin LR, ed. *Reanimation of the Paralyzed Face.* St. Louis: Mosby; 1977:241.
17. Anderl H. Cross-facial nerve transplant. *Clin Plast Surg.* 1979; 6:433.
18. Terzis JK. 'Babysitters': An exciting new concept in facial reanimation. The facial nerve. In: Castro D, ed. *Proceedings of the Sixth International Symposium on the Facial Nerve*, Rio de Janeiro, Brazil, October 2–5, 1988. Amsterdam, Berkeley, Milano: Kugler & Ghedini; 1990:525.
19. Kalantarian B, Rice DC, Tiangco DA, Terzis JK. Gains and losses of the XII-VII component of the "baby-sitter" procedure: A morphometric analysis. *J Reconstr Microsurg.* 1998;14:459–471.
20. Mersa B, Tiangco DA, Terzis JK. Efficacy of the "baby sitter" procedure after prolonged denervation. *J Reconstr Microsurg.* 2000;16:27–35.
21. Endo T, Hata J, Nakayama Y. Variations on the "babysitter" procedure for reconstruction of facial paralysis. *J Reconstr Microsurg.* 2000;16:37–43.
22. Yoleri L, Songür E, Mavioglu H, Yoleri O. Cross-facial nerve grafting as an adjunct to hypoglossal-facial nerve crossover in reanimation of early facial paralysis: Clinical and electrophysiological evaluation. *Ann Plast Surg.* 2001;46:301–307.
23. Conley J, May M. Perspectives in facial reanimation: VI. Rehabilitation techniques for acute and long-standing facial paralysis. In: May M, Schaitkin BM, eds. *The Facial Nerve.* May's 2nd ed. New York: Thieme; 2000:551–570.
24. Terzis JK, Schnarrs RH. Facial nerve reconstruction in salivary gland pathology: A review. *Microsurgery* 1993;14:355–367.
25. Pensak ML, Jackson GC, Glasscock ME. Facial reanimation with the VII-XII anastomosis: Analysis of the functional and psychological results. *Otolaryngol Head Neck Surg.* 1986;94: 305–310.
26. Kunihiro T, Higashino K, Kanzaki J. Classic hypoglossal-facial nerve anastomosis after acoustic neuroma resection: A review of 46 cases. *J Otorhinolaryngol Rel Spec.* 2003;65:1–6.
27. Frey M, Koller R, Liegl C, Happak W, Gruber H. Role of a muscle target organ on the regeneration of motor nerve fibres in long nerve grafts: A synopsis of experimental and clinical data. *Microsurgery* 1996;17:80–88.
28. Miehlke A, Stennert E. A new concept in management of facial palsy. *Am J Otol.* 1984;5:516–519.
29. May M, Schaitkain BM. History of facial nerve surgery. *Facial Plast Surg.* 2000;16:301–307.
30. Noah EM, Williams A, Jorgenson C, Skoulis TG, Terzis JK. End-to-side neurorrhaphy: A histologic and morphometric study of axonal sprouting into an end-to-side nerve graft. *J Reconstr Microsurg.* 1997;13:99–106.
31. Manni JJ, Beurskens CHG, van de Velde C, Stokroos RJ. Reanimation of the paralyzed face by indirect hypoglossal-facial nerve anastomosis. *Am J Surg.* 2001;182:268–273.
32. Hammerschlag PE. Facial reanimation with jump interpositional graft hypoglossal facial anastomosis and hypoglossal facial anastomosis: Evolution in management of facial paralysis. *Laryngoscope* 1999;109:1–23.
33. May M, Sobol SM, Mester SJ. Hypoglossal-facial nerve interpositional-jump graft for facial reanimation without tongue atrophy. *Otolaryngol Head Neck Surg.* 1991;104:818–825.
34. May M. Nerve substitution techniques: XII-VII hook-up, XII-VII jump graft, and cross-face graft. In: May M, Schaitkin BM, eds. *The Facial Nerve.* 2nd ed. New York: Thieme; 2000:611–634.
35. Koh KS, Kim J, Kim CJ, Kwun BD, Kim S. Hypoglossal-facial crossover in facial-nerve palsy: Pure end-to-side anastomosis technique. *Br J Plast Surg.* 2002;55:25–31.
36. Atlas MD, Lowinger DSG. A new technique for hypoglossal-facial nerve repair. *Laryngoscope* 1997;107:984–991.
37. Conley J. The treatment of long-standing facial paralysis: A new concept. *Trans Am Acad Ophthalmol Otolaryngol.* 1975; 78:386–392.
38. Sawamura Y, Hiroshi A. Hypoglossal facial nerve side-to-end anastomosis for preservation of hypoglossal function: Results of delayed treatment with a new technique. *J Neurosurg.* 1997; 86:203–206.
39. Cooper TM, McMahon B, Lex C, et al. Cross-facial nerve grafting for facial reanimation: Effect on normal hemiface motion. *J Reconstr Microsurg.* 1996;12:99–103.
40. Diels JH, Combs D. Neuromuscular retraining for facial paralysis: Rehabilitation of neurotologic diseases. *Otolaryngol Clin North Am.* 1997;30:727–743.
41. Bach-y-Rita P, Bach-y-Rita EW. Biological and psychosocial factors in recovery from brain damage in humans. *Can J Psychol.* 1990;44:148–165.
42. Lundborg G. Brain plasticity and cortical remodeling. In: *Nerve Injury and Repair: Regeneration, Reconstruction and Cortical Remodeling.* 2nd ed. New York: Elsevier-Churchill Livingstone; 2004:211.
43. 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: 1472–1479.