"Babysitter" Procedure with Concomitant Muscle Transfer in Facial Paralysis

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Background: The "babysitter" procedure combines cross-facial nerve grafting with segmental transfer of the hypoglossal to the affected facial nerve. Introduced by Terzis in 1984, the technique can produce satisfactory to excellent results. In long-lasting paralysis, nonetheless, the babysitter procedure may need to be combined with a muscle(s) flap(s) for outcome upgrading, which was the focus of the present study.
Methods: Thirty-eight patients had the babysitter procedure over a 20-year period (1984 to 2003). Twenty patients had only the babysitter procedure, whereas 18 needed an additional muscle flap(s) (up to three) to enhance function and cosmesis. These muscles included nine free (gracilis, pectoralis minor) and 20 regional (frontalis, minitemporalis, platysma, digastric) muscles for distinct target needs: eye closure, smile restoration, and lower lip depression. The need for a muscle flap was determined at the initial consultation. All free muscles were transferred at the second-stage of the babysitter procedure, whereas regional muscles were also transposed later. Three independent observers graded the results at two time intervals, preoperatively and 2 years after all operations were completed.
Results: The average postoperative grading scores were significantly higher compared with preoperative scores for eye closure, smile, lower lip depression, and overall aesthetic outcome ($p < 0.0001$, Wilcoxon signed ranks test). All patients had upgrading of overall aesthetics and smile, whereas four maintained similar scoring for eye closure and one maintained similar scoring for lip depression. All but two had secondary procedures to further enhance facial symmetry.
Conclusion: The babysitter procedure in conjunction with muscle transfers in selected patients with late presentation can provide highly satisfactory results when seeking uncompromising outcome. (*Plast. Reconstr. Surg.* 124: 1142, 2009.)

The "babysitter" procedure is a facial reanimation procedure introduced by Terzis[1] in 1984 as a method of preserving the bulk of the paralytic facial muscles while axonal regeneration through cross-facial nerve grafts ensues. By coapting 40 percent of the ipsilateral hypoglossal[2] (minihypoglossal) to the trunk of the affected facial nerve during the first stage of the cross-facial nerve graft, faster reinnervation of the paralytic muscles is accomplished. At the second stage, approximately 9 to 12 months later, the distal ends of cross-facial nerve grafts are coapted to distal branches of the affected facial nerve, whereas the minihypoglossal to facial nerve coaptation remains intact. The benefit of the procedure is dual: quick recovery of the facial musculature from a powerful ipsilateral motor donor without loss of original function and coordinated movement. Experimental and clinical studies have demonstrated the efficacy of the babysitter procedure,[3,4] and results have been rewarding,[4–6] provided that the affected facial nerve is in-continuity.

A close collaboration between the surgeon and electromyographer is critical for the management of

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Received for publication January 12, 2009; accepted March 20, 2009.
Presented in part at the Fourth Congress of the World Society of Reconstructive Microsurgery, in Athens, Greece, June 23 through 26, 2007.

DOI: 10.1097/PRS.0b013e3181b2b8bc

Disclosure: *Neither author has any financial interest or commercial association related to the information presented in this article. There are no conflicts of interest that require disclosure.*

these cases. The preoperative consultation is the platform on which the surgeon, the electromyographer, and the patient consult together for a comprehensive management plan. In cases of complete clinical paralysis with short denervation time (6 to 9 months) and needle electromyographs depicting fibrillations, the two-stage babysitter procedure is recommended, which usually suffices to resuscitate the facial musculature and restore gratifying coordinated symmetrical animation. *In later cases* with denervation over 9 months, it is critical to ascertain the continuity of the affected facial nerve. If the facial nerve following tumor extirpation has remained in-continuity, elicited signals on needle electromyographs will still display some fibrillations, which indicate that some facial muscle is still present. Because of a longer denervation period, the patient has to be warned that, on reinnervation, there may not be adequate functional restoration and therefore additional muscle will need to be imported for a satisfactory result. If after the first stage of the babysitter procedure a modest degree of reanimation ensues, local muscle units are recommended for the appropriate targets. *In late cases*, with denervation over 24 months, if there are hints through sparse fibrillation potentials that minimal muscle tissue may still be present, the babysitter procedure is still recommended but the patient is alerted that a free muscle transfer will definitely be required.

The wisdom of proceeding with the babysitter procedure, in these late cases, is that there is a possibility that some function might return[7] from the powerful ipsilateral motor donors that will make secondary procedures more successful. For example, a trace of returning blink and eye closure can be secondarily strengthened with direct eye sphincter neurotization alone and obviate the need for dynamic muscle substitution. A newly forming nasolabial fold, even if insufficient for a smile, will make free muscle transplantation for smile more successful, as the beginning of the smile has already been formed. A reinnervated depressor complex, even if inadequate to achieve symmetrical lower lip depression, can be addressed with additional direct neurotization of the depressor muscles, which obviates the need for platysma or digastric transfers. Provided that the patients clearly understand the sequence of events in the reanimation process and the logical explanation behind each recommendation, they will be willing participants to their overall rehabilitation journey.

Three distinct facial regions should be addressed separately and corrected appropriately: (1) the eye sphincter, (2) the lip levators, and (3) the lower lip depressors. Some of the cross-facial nerve grafts will be used to reinnervate several of these newly imported muscles, whereas the remaining will be coapted to corresponding distal branches of the affected nerve. This report summarizes the senior author's (J.K.T.) experience with the babysitter procedure in late cases combined with muscle augmentation.

PATIENTS AND METHODS

From January of 1984 to December of 2003, 38 patients had the babysitter procedure for unilateral facial paralysis. Twenty patients had the babysitter procedure alone, and the results have been reported.[4] Eighteen patients required muscle(s) importation for further enhancement of the outcomes.

Patient demographics are summarized in Table 1. Based on the duration of the paralysis, the patients were divided into four groups: denervation periods of 8 to 12 months (four patients), 12 to 24 months (three patients), 25 to 36 months (five patients), and longer than 36 months (mean, 52 months) (six patients). All patients with denervation time longer than 12 months had the affected facial nerve in-continuity, and preoperative needle electromyographs elicited fibrillations in the involved muscles.

The length of follow-up was 2 to 17 years (mean, 4 years). The operative drawings and patient charts were reviewed. Detailed documentation of clinical findings and needle electromyographs is standard practice in our unit and instrumental for following the progress of the patients. Moreover, the patients were photographed and videotaped during preoperative and postoperative office visits in a standardized fashion for comparative purposes. Demonstration of eye closure, blink reflex, soft smile, full smile with dental show, and lower lip depression without smiling was acquired.

Three independent assessors, fellows in the Reconstructive Microsurgery Program who had not been involved in any of the procedures, reviewed and graded the preoperative and postoperative videos (at 2 years after completion of all procedures) using the Terzis grading scales[4,8–10] for eye closure, smile, lower lip depression, and overall aesthetic and functional outcome (Tables 2 through 4). The study was conducted following approval by the Eastern Virginia Medical School Institutional Review Board.

Operations

During the first stage of the babysitter procedure, 40 percent of the ipsilateral hypoglossal

Table 1. Patient Demographics

Patient	Age (yr)	Sex	Side	Cause	Denervation Time (mo)	Patient Grouping Based on Denervation Time (mo)	Other Cranial Nerves Involved
1	39	F	R	Tumor	8	1 (<12)	V
2	21	F	L	Trauma	48	4 (>36)	V
3	18	F	L	Tumor	25	3 (24–36)	None
4	22	F	R	AVM	56	4 (>36)	None
5	46	F	L	Tumor	26	3 (24–36)	V, VIII
6	55	F	R	Tumor	9	1 (<12)	VIII
7	35	M	L	Tumor	12	1 (<12)	VIII
8	24	M	L	Tumor	53	4 (>36)	V
9	28	F	R	Infection	96	4 (>36)	VIII
10	51	F	R	Tumor	36	3 (24–36)	IV, V, VIII
11	61	F	R	Tumor	12	1 (<12)	None
12	16	F	L	Iatrogenic	23	2 (12–24)	None
13	31	F	L	Tumor	31	3 (24–36)	VIII
14	26	M	L	PCH	39	4 (>36)	None
15	21	F	L	Tumor	38	4 (>36)	None
16	33	M	L	Tumor	15	2 (12–24)	VIII bilaterally
17	40	F	L	Tumor	33	3 (24–36)	VIII, IX
18	37	M	L	Trauma	14	2 (12–24)	III, IV, V, VI

AVM, arteriovenous malformation; PCH, pontine cavernous hemangioma; F, female; M, male; R, right; L, left.

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	Grading	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

*Used for the grading of smile and overall aesthetic outcome.

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

nerve (minihypoglossal) was coapted to the affected facial nerve, whereas the cross-facial nerve grafts were coapted to selected distal branches of the unaffected facial nerve and tunneled across the face.[4] Five patients had three cross-facial nerve grafts, and 13 patients had four (Table 5).

At the second stage of the babysitter procedure, 9 to 15 months later, the cross-facial nerve grafts were connected to selected distal branches of the affected facial nerve, whereas some were used to innervate the free gracilis, pectoralis minor, anterior belly of the digastric muscle, or the frontalis muscle. The minihypoglossal to facial nerve coaptation was left intact.

All free muscles were transferred at the second stage of the babysitter procedure (Tables 5 and 6). Eight patients had free gracilis (Figs. 1 and 2) and one had free pectoralis minor muscle transfer. Also, during the second stage, five patients had regional muscle transfer.

Six to 26 months after the babysitter procedure (mean, 18 months), 10 patients (55.5 percent) went through a third stage that involved the importation of regional muscle(s). After each operative stage, the patients followed standard rehabilitation techniques described in previous reports.[4,11,12] For a detailed description of the surgical procedures, the reader is encouraged to access previous publications from this unit.[2,4,8–18]

Regional Muscle Transfers

Minitemporalis transfer was used for enhancement of smile in eight patients[12,13] (Figs. 3 and 4) and eye closure in one.

Frontalis Transfer

The median segment of the contralateral frontalis muscle[10,14] was transferred to the paralyzed

Table 5. Stages of the Babysitter Procedure Combined with Muscle Transfers

Patient	First Stage	Time between First and Second Stages (mo)	Second Stage	Third Stage
1	CFNG (×4) and mini-XII–VII	9	Microcoaptation of CFNGs*	Minitemporalis, platysma
2	CFNG (×3) and mini-XII–VII	9	Microcoaptation of CFNGs and free gracilis	Digastric
3	CFNG (×4) and mini-XII–VII	11	Microcoaptation of CFNGs and free gracilis	Minitemporalis
4	CFNG (×4) and mini-XII–VII	15	Microcoaptation of CFNGs and minitemporalis	
5	CFNG (×4) and mini-XII–VII	14	Microcoaptation of CFNGs and minitemporalis	
6	CFNG (×4) and mini-XII–VII	13	Microcoaptation of CFNGs and free gracilis	Minitemporalis
7	CFNG (×4) and mini-XII–VII	12	Microcoaptation of CFNGs	Digastric
8	CFNG (×4) and mini-XII–VII	14	Microcoaptation of CFNGs and free gracilis	Frontalis
9	CFNG (×4) and mini-XII–VII	8	Microcoaptation of CFNGs and free gracilis	Platysma
10	CFNG (×4) and mini-XII–VII	9	Microcoaptation of CFNGs and platysma, minitemporalis	Frontalis
11	CFNG (×3) and mini-XII–VII	10	Microcoaptation of CFNGs and minitemporalis	
12	CFNG (×3) and mini-XII–VII	11	Microcoaptation of CFNGs and platysma, minitemporalis	
13	CFNG (×4) and mini-XII–VII	15	Microcoaptation of CFNGs and free gracilis	
14	CFNG (×4) and mini-XII–VII	12	Microcoaptation of CFNGs and free gracilis	
15	CFNG (×3) and mini-XII–VII	13	Microcoaptation of CFNGs and free gracilis	Digastric
16	CFNG (×3) and mini-XII–VII	10	Microcoaptation of CFNGs	Minitemporalis, platysma
17	CFNG (×4) and mini-XII–VII	12	Microcoaptation of CFNGs and free pectoralis minor	
18	CFNG (×4) and mini-XII–VII	13	Microcoaptation of CFNGs	Platysma

CFNG, cross-facial nerve graft; XII, hypoglossal nerve; VII, facial nerve.
*"Microcoaptations of CFNGs" implies microcoaptation to distal branches of the affected facial nerve.

Table 6. Transferred Muscles That Supplemented the Babysitter Procedure

Patient	Muscle for Eye Closure	Muscle for Smile	Muscle for Lip Depression
1		Minitemporalis	Platysma
2		Free gracilis	Digastric
3		Free gracilis and minitemporalis	
4		Minitemporalis	
5		Minitemporalis	
6			Digastric
7		Free gracilis and minitemporalis	
8	Frontalis	Free gracilis	
9		Free gracilis	Platysma
10	Frontalis	Minitemporalis	Platysma
11	Minitemporalis		
12		Minitemporalis	Platysma
13		Free gracilis	
14		Free gracilis	
15		Free gracilis	Digastric
16		Minitemporalis	Platysma
17		Free pectoralis minor	
18			Platysma

side to substitute for the missing eye sphincter. The upper cross-facial nerve graft carrying motor fibers dedicated to eye closure directly neurotized the muscle (Fig. 5).

Platysma Transfer

If the ipsilateral platysma had adequately recovered following the first stage of the babysitter procedure, it could be used to substitute for lower lip depressors[9] (Fig. 4). When the platysma is denervated, transfer of the anterior belly of the digastric muscle is the next option. The anterior belly of the digastric muscle transfer is achieved through a submental incision.[9] The mylohyoid nerve is coapted to the lower cross-facial nerve graft for synchronized lip depression with the contralateral side (Figs. 1 and 6).

Statistical Analysis

The software package SPSS 12.0 (SPSS, Inc., Chicago, Ill.) was used for statistical analysis. The data obtained were averaged across the three evaluators. Results of statistical tests were considered significant at an α level of 0.05. The Wilcoxon signed ranks test was used to compare preoperative and postoperative averaged scores. The Spearman correlation coefficient was used to test the correlation between outcomes and various parameters such as denervation time.

RESULTS

Secondary Procedures

All but two patients had secondary procedures to further enhance the overall outcome. These procedures were performed either during the babysitter procedure and muscle transfers or dur-

Fig. 1. Patient 2. A 21-year-old woman presented with complete left-sided facial paralysis following trauma resulting from a motor vehicle accident. The denervation time was 48 months, but the facial nerve was in-continuity. She had the first stage of the babysitter procedure with three cross-facial nerve grafts and minihypoglossal to facial nerve coaptation. Nine months later, she had free gracilis muscle for reanimation of the smile coapted with the middle cross-facial nerve graft. The upper cross-facial nerve graft was coapted to the distal upper zygomatic branch dedicated to the eye on the affected side. A third stage was performed 10 months later, when she had transfer of the anterior belly of the digastric muscle to the lower lip (innervated with the lower cross-facial nerve graft) and placement of a palpebral spring to the left upper eyelid and minitendon graft for suspension of the left lower eyelid. (*Above, left* and *right*) Preoperative and postoperative smile and overall appearance. Preoperatively, the smile was graded as poor (1.3); postoperatively, the grading was good (4). Close-up views demonstrate (*below*, *left*) preoperative and (*below*, *right*) postoperative lower lip depression. Before surgery, the lower lip depression was graded as poor (0.5). After completion of operations, the grading was good for lower lip depression (1.5).

ing a later stage (Table 7). They included placement of a palpebral spring or gold weight[15] to the upper eyelid in combination with minitendon graft[16] to the lower eyelid and neurotization of the cornea by use of contralateral supraorbital and supratrochlear nerves in patients with neuropathic keratopathy[17] caused by concomitant involvement of the trigeminal nerve. Brow lift, genioplasty, cheek debulking, neck defatting, and temporoparietal fascia transfer to cover rippling caused by a previously transferred gracilis muscle[18] were also performed. In this study, the aesthetic

Fig. 2. Patient 9. A 38-year-old woman presented with right-sided facial paralysis caused by Ramsay-Hunt syndrome. She also had involvement of the eighth cranial nerve. The denervation time at the first stage of the babysitter procedure was 96 months. She had four cross-facial nerve grafts and minihypoglossal to facial nerve transfer. Eight months later, she had free gracilis flap for smile restoration. The obturator nerve was coapted to cross-facial nerve grafts 2 and 3. The upper cross-facial nerve graft was coapted to the corresponding upper zygomatic branch and the lower cross-facial nerve graft was coapted to the marginal mandibular branch of the affected facial nerve. She underwent a third stage 10 months later, with platysma transfer to the right lower lip, rhinoplasty, and correction of right alar flaring. Four years later, she had debulking and minilift of the right cheek. (*Left*) Smile before the second stage of the babysitter procedure and the gracilis transfer. (*Right*) Smile at 2 years after the completion of all operations. The postoperative grading by the independent reviewers for smile on the aesthetic evaluation was good (4).

outcome was assessed after the completion of all procedures (including secondary) and, although no grading was performed immediately before the secondary procedures for comparison, our previous studies demonstrated a clear benefit.[15–18]

Eyelid Closure

Three patients (16.6 percent) had muscle transfer for dynamic restoration of eye closure (Fig. 5), whereas corrections were made by means of a palpebral spring, gold weight, or lower lid minitendon graft in another eight patients (Tables 6 through 8), at the second stage of the babysitter procedure or later. All but four patients (who remained the same) had an increase in the averaged assessment scores (Fig. 7). The improvement between the preoperative and postoperative scores was statistically significant ($z = -3.306$, $p < 0.001$) (Table 8).

Smile

Fifteen patients (83.3 percent) had muscle transfer for smile improvement (Figs. 1 through 4). All patients increased the mean scores (Fig. 8), with a statistically significant difference ($z = -3.736$, $p < 0.0001$). Three patients who did not have muscle transfer for smile also had an upgraded preoperative result because of the babysitter procedure (Table 9). Statistical analysis indicated that the correlation of the aesthetic scores with the scores for the smile was more powerful compared with the scores for eye closure and lip depression.

Lower Lip Depression

All but one patient upgraded the preoperative scores (Table 8 and Fig. 9). Nine patients (50 percent) who had muscle transfer for lower lip depression (Figs. 1, 4, and 6) showed statistically significant improvement ($z = -2.680$, $p < 0.007$); the other half that did not have any additional muscle for lip depression had also demonstrated enhancement from the babysitter procedure only, which was shown to be of statistical significance ($z = -2.533$, $p < 0.011$). The difference

Fig. 3. Patient 1. A 39-year-old woman presented with complete right-sided facial paralysis following extirpation of an acoustic neuroma. The trigeminal (fifth) nerve was also involved. Medial and lateral tarsorrhaphy was performed elsewhere. The denervation time was 8 months. She had the first stage of the babysitter procedure with four cross-facial nerve grafts and minihypoglossal to facial nerve coaptation. Eight months later, she had microcoaptation of the cross-facial nerve grafts to branches of the facial nerve. Six months after the completion of the babysitter procedure, she had opening of the tarsorrhaphies and a corneal neurotization procedure[17] using the left supraorbital and supratrochlear nerves. Twenty-six months after the babysitter procedure, the right minitemporalis muscle was transposed for enhancement of smile, platysma transfer was performed for enhancement of right lower lip depression, and placement of a palpebral spring to the right upper eyelid and palmaris longus minitendon grafting were performed for suspension of the right lower eyelid. (*Left*) Preoperative appearance with the patient attempting to smile. Note the right complete facial paralysis. (*Right*) Postoperative appearance and smile at 2 years after completion of operations. The mean grading for smile was poor (1.3) before surgery and excellent (4.6) after the operations.

for all patients together was significant ($z = -3.642$, $p < 0.0001$).

Overall Aesthetic Assessment

The patients were scored from videos taken at the first office visit and 2 years from the completion of all procedures (Table 10). They all increased their mean score at the postoperative evaluation, and the difference was statistically significant ($z = -3.751$, $p < 0.0001$, Wilcoxon matched-pairs signed rank test) (Figs. 1 through 4 and 10).

Needle Electromyographic Results

The muscle volitional effort as expressed on electromyography was graded as shown in Table 11. Electromyography showed improvement with presence of evoked potentials or full electrogenesis postoperatively. Dual innervation (from cross-facial nerve grafts and minihypoglossal) was possible to be separated, and the preoperative and postoperative (at 2 years after completion of the babysitter procedure) difference in the results was of statistical significance ($p < 0.0001$, Wilcoxon signed rank test). The minihypoglossal provided stronger responses.

Patient age was found to be correlated with postoperative outcome regarding eye closure ($p < 0.001$), as younger patients (<35 years old) had superior results. No difference was seen for the rest of the outcome measurements.

Fig. 4. Patient 12. A 16-year-old girl presented with left-sided facial paralysis as a result of iatrogenic injury from orthognathic surgery. The denervation time was 23 months. During the first stage, she had three cross-facial nerve grafts and hypoglossal to cervicofacial branch of the affected facial nerve transfer in an end-to-side fashion by means of interposition nerve grafts. Eleven months later, she had secondary microcoaptation of the cross-facial nerve grafts, genioplasty, and transfer of the left minitemporalis for enhancement of smile and platysma for restoration of left lower lip depression. (*Above*, *left*) Smile before the second stage of the babysitter procedure and the minitemporalis muscle transfer. (*Above*, *right*) The final result for smile was considered as good for overall aesthetics. Close-up view showing (*below*, *left*) lower lip depression before the second stage of the babysitter procedure and (*below*, *right*) at 2 years after the platysma muscle transfer. The lower lip depression at 2 years after all operations was considered excellent.

The denervation time was not significantly correlated with the outcome scores for eye closure, smile, lip depression, or overall aesthetics (Table 12). Because outcomes from the babysitter procedure alone are extremely sensitive to denervation time, this could mean that the importation of new muscles and secondary procedures negated the influence of denervation time on the final outcome. In addition, the small number of patients (four and three, respectively) in the first two groups of denervation time could have influenced the correlation.

DISCUSSION

To reproduce the fine and intricate expressions of the face is an almost unobtainable goal, especially when the reconstructive surgeon is challenged with late cases of complete facial paralysis.[19–23] The best prognosis for a result that almost mimics the con-

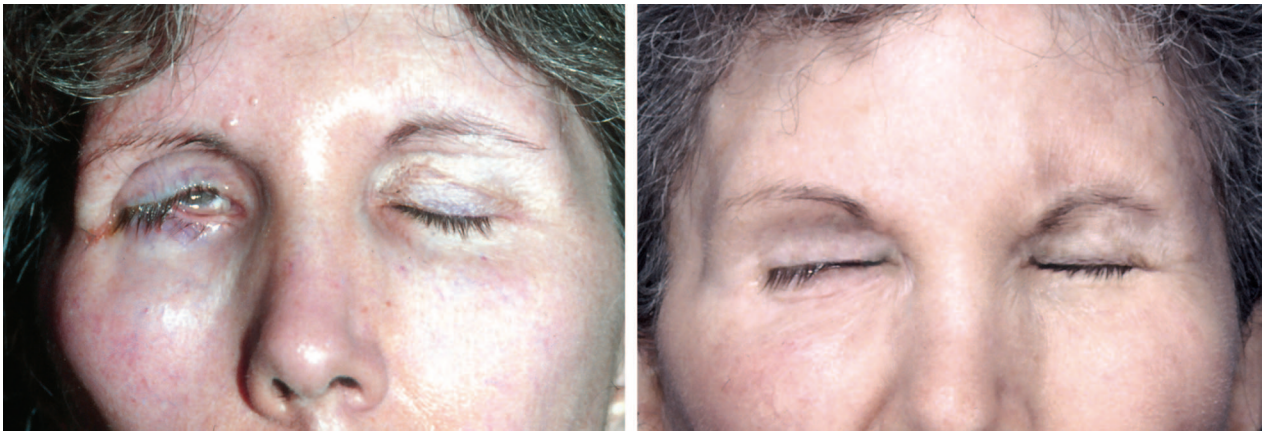

Fig. 5. Patient 10. A 51-year-old woman presented with right-sided complete facial paralysis following extirpation of clivus meningioma. The lateral tarsorrhaphy was performed elsewhere. She also had involvement of the fourth, fifth, and seventh cranial nerves. The denervation time was 36 months at the first stage of the babysitter procedure, which involved four cross-facial nerve grafts and minihypoglossal to facial nerve transfer. Ten months later, she proceeded with the second stage, which involved secondary microcoaptations of three cross-facial nerve grafts and transfer of minitemporalis to the upper lip and platysma to the lower lip. In a third stage, 13 months later, the contralateral frontalis was transferred to the right upper and lower eyelids (innervated with the most superior cross-facial nerve graft) and direct corneal neurotization by the contralateral supraorbital and supratrochlear nerves. (*Left*) Preoperative eye closure and (*right*) following the contralateral frontalis transfer. The preoperative eye closure was graded as poor (1.66) and improved to nearly complete (4) postoperatively.

Fig. 6. Patient 6. A 35-year-old man presented with left-sided facial paralysis (following extirpation of acoustic neuroma) with concomitant involvement of the eighth nerve. The denervation time at the first stage of the babysitter procedure was 12 months. He had four cross-facial nerve grafts and minihypoglossal to facial nerve transfer. Twelve months later, at the second stage, he had microcoaptation of three cross-facial nerve grafts and insertion of a palpebral spring and minitendon graft to the left lower eyelid. Eleven months later, he underwent a third stage, with transfer of the anterior belly of the digastric, innervated by the lower fourth cross-facial nerve graft and revision of the palpebral spring. (*Left*) Lower lip depression before the third stage. (*Right*) Lower lip depression at 2 years after completion of all operations. The result was considered by the assessors as excellent.

tralateral side is reserved for those patients who have early repair of the facial nerve. The babysitter procedure is a method of salvaging the denervated facial musculature from atrophy until new motor axons from the contralateral facial nerve reach the targets. Quick muscle reinnervation with the eventual possibility of coordinated movements is its main goal. However, in late cases, despite how carefully the patients are selected for the procedure, functional recovery remains unpredictable. Thus, discussing the options with the patient is pivotal, and they must also be prepared for multiple stages of reconstruction, especially when reanimation needs to address the three separate zones of the face: upper, middle, and lower.

Table 7. Secondary Procedures

Patient	Second Stage	Third Stage	Later Stage
1		Neurotization of cornea, mediolateral canthopexy	
2			Palpebral spring and minitendon graft, neurotization of cornea, tightening of gracilis muscle
3			Palpebral spring and minitendon graft
4			Palpebral spring and minitendon graft
5	Neurotization of cornea, brow lift		
6	Palpebral spring and minitendon graft	Revision of palpebral spring	
7		Superficial temporal fascia transferred over gracilis	
8		Neurotization of cornea	
9			Cheek debulking, alar base and columella adjustment
10			Corneal neurotization
11			
12	Genioplasty		Dermal/fat graft to correct donor-site temporal depression
13			Advancement of gracilis, sculpturing cheek and neck, gold weight and minitendon graft
14	Palpebral spring and minitendon		Revision of palpebral spring
15		Sculpturing cheek and neck, gold weight to the upper eyelid	Minitendon graft to lower eyelid
16		Gold weight and minitendon graft	
17			
18		Neurotization of cornea	

Table 8. Averaged Scores of Outcomes for Eye Closure and Lower Lip Depression Given by the Three Assessors Using the Terzis Grading Scales*

Patient	Preoperative Eye Closure	Postoperative Eye Closure	Preoperative Lip Depression	Postoperative Lip Depression
1	3.67	4.67	0.50	1.00
2	3.00	3.00	1.00	1.50
3	3.00	3.00	1.00	1.00
4	2.67	4.00	0.83	1.17
5	2.33	4.00	0.33	0.83
6	4.00	4.67	0.50	1.00
7	2.33	4.33	0.66	1.33
8	4.67	4.67	0.33	0.83
9	4.00	5.00	0.50	1.17
10	2.67	3.00	0.33	1.00
11	3.00	3.67	0.16	0.67
12	4.00	4.67	1.00	1.33
13	2.67	3.33	0.66	1.50
14	3.67	4.00	0.66	0.83
15	4.00	4.33	0.50	1.33
16	3.33	4.33	0.50	0.83
17	4.00	4.00	0.33	0.83
18	2.00	3.33	0.00	0.67

*The difference was statistically significant ($p < 0.001$ for eye closure and $p < 0.0001$ for lower lip depression, Wilcoxon signed ranks test). The mean values were 3.278 ± 0.752 and 4.000 ± 0.647, respectively, for preoperative and postoperative eye closure and 0.543 ± 0.285 and 1.045 ± 0.266 for preoperative and postoperative lip depression.

The babysitter procedure is intrinsically a two-stage procedure, and the potential for muscle recovery is assessed preoperatively and determined more precisely before the second stage, clinically and electrophysiologically. Patients who fail to show measurable clinical and needle electromyographic improvements will proceed with muscle(s) flaps during subsequent operations.

Temporalis muscle transfer was first proposed by Gillies[24] in 1934 and further developed by

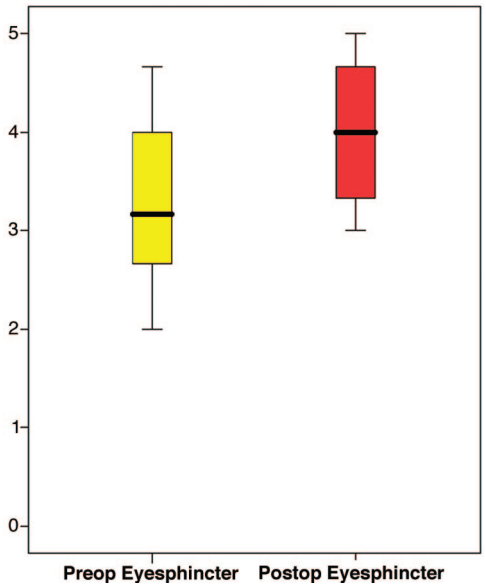

Fig. 7. Grading of the preoperative and postoperative eye closure. The *dark line* is the median value. The difference of the *ends of the whiskers* is the range. The *end of the box* is the interquartile range. The difference is statistically significant ($z = -3.306$, $p < 0.001$, Wilcoxon signed ranks test).

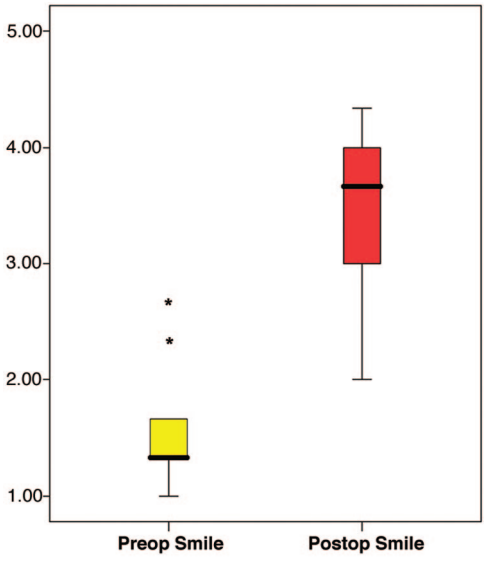

Fig. 8. Grading of the preoperative and postoperative smile. The *dark line* is the median value; outliers are marked by *asterisks*. The difference of the *ends of the whiskers* is the range. The *end of the box* is the interquartile range. The difference is statistically significant ($z = -3.736$, $p < 0.0001$, Wilcoxon signed ranks test).

Andersen[25] in 1961 as a treatment modality for paralytic lagophthalmos. Other authors[26–28] more recently reported the deployment of minitemporalis muscle for this purpose. Slips of the central part of temporalis muscle, 2 to 2.5 cm wide, elongated with slings of the deep temporal fascia were tunneled through the eyelids. A similar technique has been reported by our center,[10,14] with attention paid to ensuring that the tunnel at the lower eyelid is closer to the ciliary line so that ectropion is prevented. Free flaps have been used in the management of paralytic lagophthalmos.[11] For eye closure, Frey[26] reported the use of a segment of the free gracilis muscle, whereas the rest of the muscle is used for reanimation of the midface. Two cross-facial nerve grafts provided the innervation to the two territories of the muscle. Other ways of eye sphincter substitution were reported in 1984 by Terzis, who described two homologous muscles for dynamic restoration of eye closure and blink.[10,14] These include the contralateral frontalis as a pedicle transfer (Fig. 5) and the contralateral platysma as a free vascularized innervated muscle flap.

The ocular problems are more troublesome when the trigeminal nerve is involved, resulting in neurotrophic keratopathy. In our series, apart from eye closure, the lack of corneal sensibility was addressed by performing a novel procedure—direct neurotization of the cornea by means of the contralateral supraorbital and supratrochlear nerves—with gratifying outcomes.[17] For static reconstruction of lagophthalmos and paralytic ectropion, the senior author frequently uses palpebral springs,[15] gold weights,[15] or minitendon grafts.[16]

The free muscle transfer remains the cornerstone in the reconstruction of paralyzed smile.[8,21,29–31] Free gracilis transfer has been the most common microneurovascular transfer performed for the midface since its introduction by Harii et al.,[29] especially in late established facial paralysis.[8,20,21,30,31] It can be debulked and properly molded in situ.[11] For every functional muscle transfer, placement under correct tension is of utmost importance for satisfactory outcome. Despite large experience gained over the past 30 years, it is still impossible to predict the outcomes following free muscle transfer to the face. The senior author advocates the use of the minitemporalis muscle to improve suboptimal results following a free muscle transfer,[12] or after incomplete recovery following the babysitter procedure.[13] Rubin et al.[32] managed patients with partial facial paralysis and muscle weakness with either plication of the levator muscles or, when atrophic, regional muscle transposition.

Edgerton[33] was the first to call for dynamic reanimation of the lower lip and used the anterior belly of digastric combined with fascial strips. This area of facial reanimation has been neglected. The excursion of the lower lip is important for the overall symmetry of a smile (especially for full

Table 9. Averaged Scores of Outcomes for Smile Given by the Three Assessors Using the Terzis Functional Grading Scale*

Patient	Preoperative Smile Averaged Scores	Preoperative Grading of Smile	Postoperative Smile Averaged Scores	Postoperative Grading of Smile
1	1.33	Poor	4.66	Excellent
2	1.67	Fair	4.00	Good
3	1.33	Poor	2.33	Fair
4	1.33	Poor	3.67	Good
5	1.67	Fair	4.00	Good
6	1.33	Poor	3.67	Good
7	1.33	Poor	3.67	Good
8	1.33	Poor	3.67	Good
9	2.67	Moderate	4.66	Excellent
10	1.33	Poor	3.67	Good
11	1.00	Poor	2.67	Moderate
12	2.33	Fair	4.00	Good
13	1.33	Poor	3.00	Moderate
14	1.33	Poor	3.00	Moderate
15	1.67	Fair	4.00	Good
16	1.33	Poor	3.33	Moderate
17	1.33	Poor	2.67	Moderate
18	1.33	Poor	3.33	Moderate

*The difference is statistically significant ($z = -3.736$, $p < 0.0001$, Wilcoxon signed rank test). The mean value was 1.498 ± 0.401 preoperatively and 3.555 ± 0.645 postoperatively.

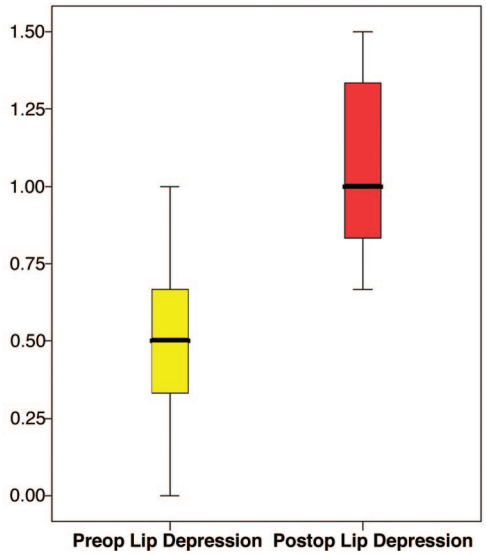

Fig. 9. Grading of preoperative and postoperative lower lip depression. The *dark line* is the median value. The difference of the *ends of the whiskers* is the range. The *end of the box* is the interquartile range. The difference is statistically significant ($z = -3.642$, $p < 0.0001$, Wilcoxon signed rank test).

denture smile) and has always been addressed aggressively in our center.[9] The babysitter procedure, minihypoglossal nerve transfers to the cervicofacial branch of the affected nerve, direct neurotizations of the depressor muscles, and regional muscle transposition (platysma, digastric) constitute our strategies for dynamic depressor restoration.[9]

The unfailing vascular anatomy (with blood supply coming off the submental artery) and innervation from the mylohyoid branch of the trigeminal nerve make the anterior belly of the digastric muscle an appealing option for reanimation of the lower lip.[9,34–37] In our technique,[9] the anterior belly is detached completely from the mandible and repositioned laterally to provide a better vector of pull, and its nerve is coapted to the lower cross-facial nerve graft carrying motor fibers from the contralateral marginal mandibular branch for coordinated and symmetrical movement.

In 1973, Edgerton et al.[38] transposed the platysma bilaterally on a Möbius patient. Futrell et al.[39] used the platysma muscle flap for intraoral reconstruction, and Fine et al.[40] published their work on innervated platysma flap for facial animation. The controversy on its blood supply has led to several recent publications,[41,42] although the senior author[9,14] in 1984 described for the first time a reliable pedicle stemming directly off the facial artery in 88 percent of cases or the submental branch of the facial artery in 12 percent. The cervical branch of the facial nerve enters the undersurface of the muscle at the lateral third from its origin.

As anticipated, the mean denervation time for the patients who needed additional muscle transfer was longer (mean, 31.8 months; range, 9 to 96 months) compared with the patients with the babysitter procedure alone (mean, 22.1 months; range, 6 to 60 months). This emphasizes the fact that prolonged denervation is linked to the necessity for new muscle supplementation. Analyzing the results in this study, it was found that

Table 10. Averaged Scores Given for Overall Aesthetics by the Three Assessors and Grading of Outcome Using the Terzis Grading Scale*

Patient	Preoperative Averaged Scores	Preoperative Grading	Postoperative Averaged Scores	Postoperative Grading
1	1.67	Fair	3.67	Good
2	1.67	Fair	3.67	Good
3	1.67	Fair	2.33	Moderate
4	1.00	Poor	3.00	Moderate
5	1.67	Fair	3.67	Good
6	1.00	Poor	3.33	Moderate
7	1.33	Poor	3.67	Good
8	1.67	Fair	3.67	Good
9	2.33	Fair	4.33	Good
10	0.67	Poor	3.67	Good
11	0.67	Poor	2.67	Moderate
12	2.00	Fair	4.00	Good
13	1.00	Poor	3.00	Moderate
14	1.67	Fair	3.67	Good
15	1.67	Fair	3.67	Good
16	1.33	Poor	3.67	Good
17	0.67	Poor	2.00	Fair
18	0.67	Poor	3.00	Moderate

*The difference is statistically significant ($z = -3.751$, $p < 0.0001$, Wilcoxon signed rank test). The mean values for overall aesthetic outcome preoperatively and postoperatively were 1.353 ± 0.503 and 3.371 ± 0.593 respectively.

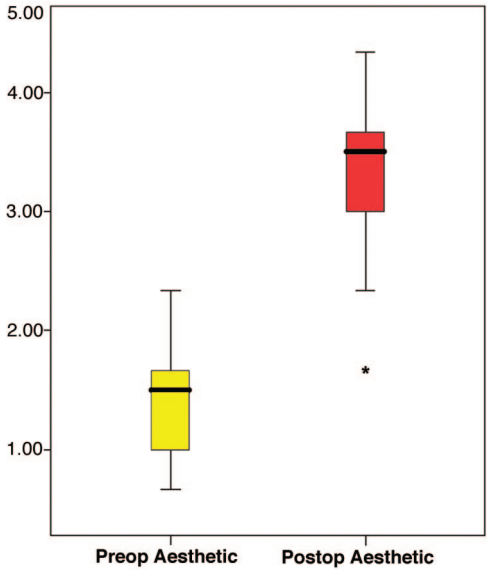

Fig. 10. Grading of the overall aesthetic preoperative and postoperative outcome. The *dark line* is the median value, and outliers are marked by *asterisks*. The difference of the *ends of the whiskers* is the range. The *end of the box* is the interquartile range. The difference is statistically significant ($z = -3.751$, $p < 0.0001$, Wilcoxon matched-pairs signed rank test).

Table 11. Grading for the Electromyography Studies (Volitional Effort)

Grade	Description	
0	No evoked potentials	−
1	Some evoked potentials	+/−
2	Moderate evoked potentials (incomplete interference pattern)	++
3	Full electrogenesis (complete interference pattern)	+++

patients who needed muscle for one area had also upgraded overall results as a consequence of the babysitter procedure. In all patients in this study, the facial nerve was in-continuity and some degree of electromyographic activity was detected preoperatively despite complete clinical paralysis. Postoperatively, the ensuing improvement in needle electromyographic results (which also demonstrated separate signals from the cross-facial nerve graft and the minihypoglossal nerve) correlated with the overall clinical improvement,[4] which constitutes a strong argument against spontaneous recovery. It is notable that denervation time was not found to correlate with the final aesthetic or functional outcomes, signifying that the transfer of muscle flap(s) corrected a potentially inadequate outcome if the reanimation was based solely on the reinnervation of the existing facial musculature. For this reason, it is critical that the babysitter procedure, when conducted in late cases, uses three or four cross-facial nerve grafts, so that one or two could be used to innervate transferred muscles.

CONCLUSIONS

In later cases of facial paralysis, with continuity of the facial nerve and electromyographic evidence of fibrillation, the babysitter procedure can be performed. Detailed consultation with the patient re-

Table 12. Spearman Correlation Test between Denervation Time and Outcome Grading for Eye Closure, Smile, Lip Depression, and Overall Aesthetics at 2 Years after Completion of Procedures*

	Postoperative Eye Closure	Postoperative Smile	Postoperative Lip Depression	Postoperative Aesthetics
Correlation coefficient	–0.120	0.136	0.230	0.162
Significance (two-tailed)	0.635	0.591	0.358	0.521

*No statistically significant correlation is seen.

garding muscle transfers and revision surgery should take place preoperatively and throughout all stages of the babysitter procedure. The participating and well-informed patient will be rewarded with a gratifying result in terms of clinical outcomes and social acceptability.

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