# Single-Stage Facial Reanimation in the Surgical Treatment of Unilateral Established Facial Paralysis

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**Background:** Surgical treatment of unilateral long-standing facial paralysis requires transposition of new musculature to restore the function of the atrophied mimetic musculature. Facial reanimation with free neuromuscular flaps is actually the accepted standard treatment. Two-stage procedures have been used for years, with a total flap recovery time of 18 to 24 months. In 1998, Harii proposed single-stage facial reanimation using the latissimus dorsi flap, showing a faster recovery compared with two-stage procedures. The present study evaluated the results of the authors' center applying the single-stage facial reanimation.

**Methods:** From April of 1999 to April of 2006, 33 patients with unilateral established facial paralysis underwent single-stage facial reanimation via latissimus dorsi free flap transplantation. Time from the onset of paralysis ranged from 20 months to 64 years (mean, 11.6 years). Patients were followed postoperatively for at least 24 months. Results were studied and compared using Terzis and Noah's 1997 classification.

**Results:** Among the 33 patients included in the study, there was an average reinnervation time of 8.9 months. According to Terzis and Noah's classification system, 12 patients (36.3 percent) were considered grade V, 12 (36.3 percent) were grade IV, four (12.2 percent) were grade III, two (6.1 percent) were grade II, and three (9.1 percent) were grade I.

**Conclusions:** Single-stage facial reanimation with a latissimus dorsi flap achieved morphofunctional results similar to those obtained with the classic two-stage technique. In addition, the authors were able to reduce the morbidity associated with treatment and the time required for recovery. (*Plast. Reconstr. Surg.* 124: 124, 2009.)

Unilateral facial paralysis results in the inability to contract the mimetic musculature and, in long-term cases, the coarse distortion of facial morphology, especially during activation of the contralateral musculature. The treatment of unilateral established facial paralysis has two goals: to reach symmetry of the face at rest and to partially restore facial movement. Facial reanimation is a surgical technique used to restore the facial mimetic musculature (i.e., the spontaneous smile) in the inferior two-thirds of the face and eyelid closing in the superior third. A series of ancillary procedures is used to optimize the morphofunctional improvements.[1]

When a long-standing facial paralysis is present, transposition of new musculature is re-

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quired to restore the function of the atrophied musculature. Today, transplantation of a muscular free flap is the accepted standard treatment, as this leads to the best morphological results.[2–6] This is accomplished by most surgeons using a two-stage technique, as suggested in 1980 by O'Brien et al.[7] The recovery time associated with this procedure is approximately 18 to 24 months. To reduce the length of treatment and recovery, Harii et al. proposed single-stage facial reanimation using muscular transplantation of the latissimus dorsi.[8] The present study evaluated the results of our center applying this technique.

## PATIENTS AND METHODS

Briefly, the single-stage facial reanimation technique involves the harvest of a muscular free flap in the thoracodorsal region and the contemporary surgical preparation of the paralyzed facial region in which the flap will be positioned (Fig. 1).

The cutaneous pocket in the face must be prepared at the subcutaneous level. Otherwise, unaesthetic cutaneous folds may occur during contraction of the flap due to strict adhesion between the skin and the transplanted muscle.

A cheek pocket is created with a preauricular incision and extended inferiorly and posteriorly to the earlobe to avoid scars into cervical region; vascular anastomoses are easily performed using facial vessels as recipients via a short incision approximately 2 cm long.

For correct formation of the nasolabial fold during contraction of the flap, the cutaneous pocket must be extended approximately 1.5 cm medially to the ideal position of the fold itself. When the flap subsequently contracts, the natural skin crease will form a new nasolabial fold symmetrical to the contralateral side. Four or five 3-0 polyethylene stitches are positioned across the residual fibers of the orbicularis oris muscle. If this is not visible, the stitches are passed through the deep subcutaneous tissue. No additional incision on the nasolabial fold or intraorally is added to insert the stitches.

A 1.5- to 2-cm incision is made on the nonparalyzed side along the lines of the cutaneous tension that correspond to the posterior edge of the musculus zygomaticus major, at which facial nerve branches are present. Activation of the levator labii superioris and zygomaticus major muscles can be evaluated using an electrostimulator. This technical step is facilitated when the profile of the musculus zygomaticus major has previously been sketched. This branch is then sectioned and subsequently anastomosed to the thoracodorsal nerve to provide motor stimulation.

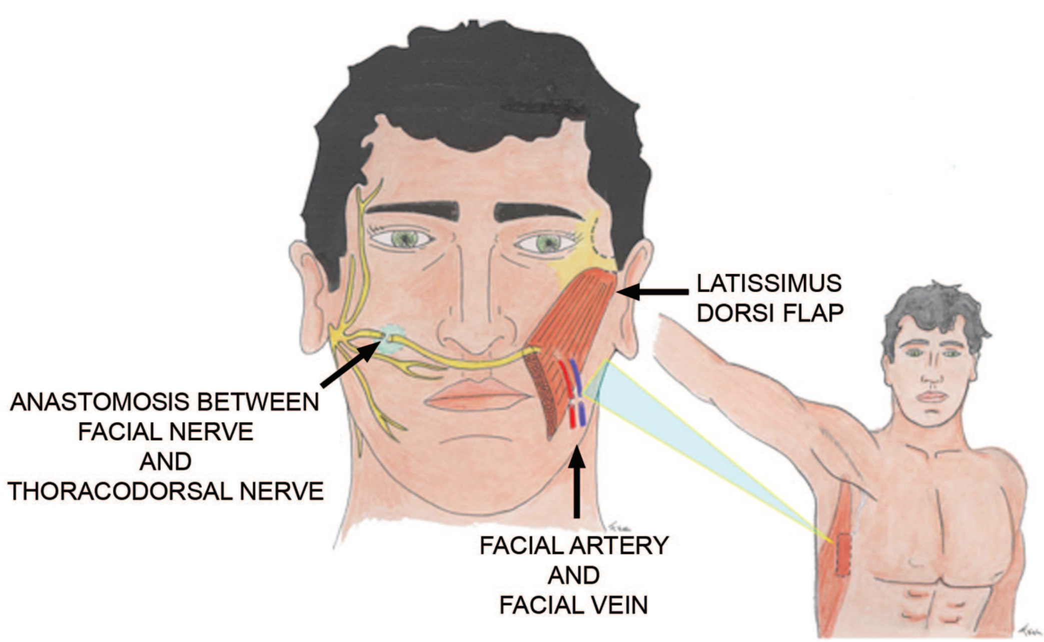


**Fig. 1.** Scheme of the single-stage facial reanimation procedure according to Harii et al. (One-stage transfer of the latissimus dorsi muscle for reanimation of a paralyzed face: A new alternative. *Plast Reconstr Surg*. 1998;102:941–951). A small portion (approximately 10 × 6 cm) of the latissimus dorsi muscle is harvested from the anterior side of it. The flap is set subcutaneously into the previously prepared cheek pocket while the nerve is anastomosed to a branch of the contralateral facial nerve.

Simultaneously, the thoracodorsal nerve is traced in the axillary region until the posterior chorda of the brachial plexus is reached. The tracing is continued for 0.5 to 1 cm, to obtain an 11- to 12-cm segment; another 3 to 4 cm may be obtained via a thin intraparenchymal dissection of the muscle, for a total segment length of 15 to 16 cm (Fig. 2).

This is the most delicate stage of the facial animation procedure, as it requires the separation of the arterial and venous thoracodorsal branches from the nerve branches; in addition, branches of the thoracodorsal nerve not destined for the muscular segment that will be transplanted must be simultaneously sacrificed. The decision regarding which section of the nerve to utilize for obtaining optimal thoracodorsal nerve length is generally based on the surgeon's experience.

After dissection of the neurovascular pedicle, a rectangular portion of the latissimus dorsi is harvested, centered on the pedicle and its bifurcations, and placed in a subfascial position on the deep surface of the muscle. Flap size is determined in accordance with the patient's facial dimensions, but generally the flap is 4 to 6 cm wide and 8 to 12 cm long. The thickness of the flap will be different in different people, ranging between 1 and 2.5 cm cranially (proximal to the modiolus once transposed) and 0.5 and 1.5 distally (at the zygomatic arch later on). The cranial margin of the flap is sectioned with a gastrointestinal stapler, as described by Asato et al.[9] This step creates an attachment medially to the nasolabial fold without having to strip the stitches. Then, the muscular free flap is settled into the cheek pocket in its final position by parachuting it on the stitches. The hilum of the pedunculus is set medially in the face to take advantage of the entire length of the thoracodorsal nerve. The thoracodorsal nerve is then transposed subcutaneously onto the contralateral hemiface to execute the nerve anastomosis. The distal edge of the muscle is fixed to the zygomatic arch; light pressure must be kept on the muscle to contrast the contracture that occurs when it is detached from the chest. The tension of the flap must be sufficient to overcorrect the operated area. If the muscle is thin and does not lead to evident bulk, it may be anchored to the deep temporalis fascia. By doing so, it is possible to use a larger contractile mass.

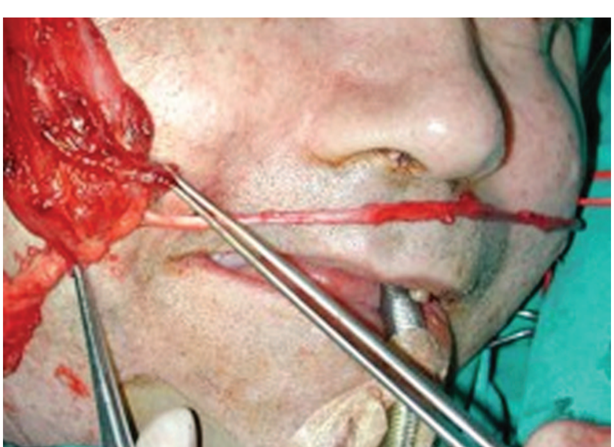

**Fig. 2.** A 15- to 16-cm segment of thoracodorsal nerve is required to reach a branch of the contralateral facial nerve.

### Patients

Thirty-three patients were operated on from April of 1999 to April of 2006 for established facial paralysis and underwent a latissimus dorsi free flap transposition. Follow-up time was 24 months. Causes of paralysis are listed in Table 1.

All patients underwent electromyographic evaluation of their mimetic musculature preoperatively to confirm established facial paralysis.[10] Patients were also interviewed regarding their personal identities, problems experienced in everyday life that were related to their pathological condition, and their ability to close their eyes, breathe through the nose, chew, and speak.

Postoperative periodical medical examinations were performed every 3 to 4 months. During each office visit, facial objectivity was evaluated at rest and during activation of the mimetic musculature.

As soon as muscle functioning began, patients were referred to the physiotherapist of our team, who taught each patient the physical training to be performed in front of a mirror and, later on, without a mirror.

**Table 1. Causes of Paralysis**

| Causes of Paralysis | No. of Patients |
|---|---|
| Sequelae of surgery for eighth nerve neurinoma | 17 (51.5) |
| Congenital paralysis | 4 (12.2) |
| Cranial base trauma | 3 (9.1) |
| Sequelae of surgery for seventh nerve neurinoma | 2 (6.1) |
| Sequelae of Bell's palsy | 2 (6.1) |
| Sequelae of excision of facial nerve hemangioma | 1 (3) |
| Sequelae of meningitis | 1 (3) |
| Sequelae of radiotherapy | 1 (3) |
| Complications of brain aneurysm | 1 (3) |
| Sequelae of the exerecis pontino hemangioma | 1 (3) |
| Total | 33 (100) |

Twenty-four months postoperatively, patients underwent a specific assessment of facial reanimation according to Terzis and Noah's classification[11] (Table 2). Results were based on photographic evaluation of facial symmetry at rest and during contraction and rated on a scale from I to V, with I considered "poor" and V considered "excellent." A panel consisting of a physiotherapist, a maxillofacial surgeon, and a maxillofacial surgery resident not involved in the operations graded the patients.

Spontaneity of flap contraction according to emotional stimulus was assessed by leaving the patient alone in a room to watch a comic movie for 10 minutes. No one was present during this time to embarrass the patient or to inhibit his or her spontaneity.

Electromyographic tests were included in a protocol of serial controls (every 2 months) to evaluate flap recovery. These controls were interrupted 6 months after the beginning of muscle contraction.

To maintain the patency of the vascular anastomoses for at least 30 days postoperatively, patients were given acetylsalicylic acid (100 mg/day). During the 5 days immediately after surgery, flap viability was evaluated via external eco-Doppler monitoring, with the probe positioned in proximity to the vascular pedicle.

### Statistical Analysis

Data were summarized by generating mean and standard deviations. Statistical analyses were conducted by using SYSTAT12 (SPSS, Inc., Cary, N.C.). A one-way analysis of variance test was performed to investigate whether the satisfaction results were distinguishable when the corresponding Terzis and Noah scale for each patient was used as a factor. Spearman rank order correlation coefficients were computed to investigate the correlation between the satisfaction results and the Terzis and Noah scale rank for each patient. Results of analyses were considered significant for $p$ values less than 0.05.

**Table 2. Final Results***

| Grade | Description | No. of Patients (%) |
|---|---|---|
| V: Excellent | Symmetry with good tone at rest; full contraction; symmetrical smile with teeth showing | 12 (36.3) |
| IV: Good | Symmetry at rest; nearly full contraction | 12 (36.3) |
| III: Moderate | Moderate symmetry at rest; moderate contraction | 4 (12.2) |
| II: Fair | No symmetry at rest; minimal contraction | 2 (6.1) |
| I: Poor | Deformity; no contraction | 3 (9.1) |

*Results were rated according to the classification of Terzis and Noah (from Terzis JK, Noah ME. Analysis of 100 cases of free-muscle transplantation for facial paralysis. *Plast Reconstr Surg.* 1997;99:1905–1921).

## RESULTS

Age at the time of operation ranged from 5 to 73 years (mean, 47.8 years; SD, 15.2 years). A total of 70 percent of patients had left facial paralysis. Time from the onset of paralysis ranged from 20 months to 64 years (mean, 5.3 years; SD, 128.4 months).

Among the 33 patients included in the study, we observed a large variability in times of onset of contraction, with an average time to reinnervation of 8.9 months (range, 50 days to 22 months; SD, 3.7 months). According to the classification system by Terzis and Noah, 12 patients (36.3 percent) were considered grade V, 12 (36.3 percent) were grade IV, four (12.2 percent) were grade III, two (6.1 percent) were grade II, and three (9.1 percent) were grade I (Table 2 and Figs. 3 through 8).

In 20 patients (60.6 percent), contraction resulted in the activation of the collateral mimetic musculature involved in the smiling movement. In two patients (6.1 percent), activation of the mimetic musculature required simultaneous closing of the contralateral eye, at least partially. In two patients (6.1 percent), activation of the transplanted muscle was more effective during the kissing movement instead of during smiling.

Two patients (6.1 percent) who had difficulty coordinating flap function with the contralateral mimetic musculature improved as they repeated exercises in front of a mirror, utilizing visual control of the movements as suggested by physiotherapist.

In one patient (3.0 percent), flap infection occurred, which is why treatment with daily washings and antibiotic therapy were necessary. The infection resolved within 1 week. The patient was rated as grade II 24 months later. In six patients (18.2 percent), prolonged muscle contraction or pseudospasm of the flap occurred, causing visible discomfort (Table 3).

If muscle tension appeared excessive or insufficient at 6 months after the onset of contraction, the flap was revised. In three patients (9.1 percent), muscular tension was slackened by disconnecting and unstacking the superior two-thirds of the flap from the superficial and deep planes and by repositioning the flap more caudally; however, this was effective in only one patient (grade III

**Fig. 3.** Case 1. (*Left*) Preoperative appearance of the face at rest. The ptosis of the midface and the deviation of the oral rim are evident. (*Right*) Preoperative appearance of the face during activation of facial mimetic musculature. The patient's face is grossly distorted.

**Fig. 4.** Case 1. (*Left*) Good recovery of the symmetry of the middle third of patient's face at rest and (*right*) during smiling due to activation of the flap.

preoperatively to grade V postoperatively, according to the classification of Terzis and Noah[11]). In the other two patients, we had to assist after renewal of the pseudospasm within a few months. These patients who underwent secondary surgery together with another two patients who had spasm of the flap were treated with local injections of botulinum toxin, which temporarily solved the pseudospasm and is still administered every 4 months. Three patients needed cranial repositioning of the muscle; one patient's score did not improve (grade III), while the other two patients moved from grade III to IV and from grade III to V. The mean improvement of the six patients who underwent secondary surgery was 0.83; from a preoperative grade of III, one patient improved to

**Fig. 5.** Case 2. Preoperatively, there is slight asymmetry of the face at rest (*left*) and during activation of the facial mimetic musculature (*right*).

**Fig. 6.** Case 2. Postoperatively, there is enhanced symmetry of the soft tissue of the lower two-thirds of the face at rest (*left*). The nasolabial fold is enhanced in comparison to the patient's preoperative appearance. (*Right*) There is good symmetry of the middle third of the face during smiling due to activation of the flap.

grade IV, two patients improved to grade V, and three patients were unchanged.

Results of electromyographic analysis did not correspond with clinical results. In most patients in whom objective functional recovery was noted, no voluntary flap activity was registered on electromyography and results of the nerve conduction test were negative. From this point of view, our study data were not reliable, and therefore are not described in this report.

In five patients (15.2 percent), we observed an excessive bulk of moderate size. In one case of more evident bulk, we reduced the thickness of the superior two-thirds of the flap during the revision and simultaneous cranial replacement of the flap. In the other cases, this procedure seemed too invasive rel-

**Fig. 7.** Case 3. Congenital facial paralysis. (*Left*) Preoperatively, ptosis of the soft tissues is enhanced, despite the patient's young age. (*Right*) There is gross distortion of the face during activation of facial mimetic musculature.

**Fig. 8.** Case 3. There is good recovery of the symmetry of the middle third of the face at rest 12 months after surgery (*left*) and during smiling due to spontaneous activation of the flap (*right*).

ative to the size of the bulk, especially when one considers that there were few complaints regarding the issue. The facial and thoracic surgical wounds healed normally in all patients.

Results of the study of audiovisual registration (while the patients were watching a comical movie) showed the spontaneity of muscle activation during smiling in all patients, when this type of observation was possible (25 patients). See **video**, **Supplemental Digital Content 1,** which demonstrates the patient laughing while watching a funny video. The spontaneity of smiling gives a more pleasant aspect to facial mimetic movements, ***http://links.lww.com/A1412***.

**Table 3. Complications***

| Complication | No. of Patients (%) |
|---|---|
| Pseudospasm | 6 (18.18) |
| Infection | 1 (3.0) |
| Synkinesis | 2 (6.1) |
| Flap loss | 0* (0.0) |

*The viability of buried flaps is not guaranteed by the use of an external Doppler probe.


**Video 1.** See **Video, Supplemental Digital Content 1,** which demonstrates the patient laughing while watching a funny video. The spontaneity of smiling gives a more pleasant aspect to face mimetic movements, ***http://links.lww.com/A1412*** .

All three patients with a grade of I were excluded from this evaluation because flap activity was null. Five patients were excluded because they did not enjoy the movies, so they did not smile or laugh at all.

All patients interviewed before surgery reported embarrassment about their appearance (most of them talked with a hand covering the paralyzed cheek) and cited this as the reason for undergoing surgery. All patients complained about same difficulties on the pathological side during nasal inspiration and reported involuntarily biting of the cheek while chewing. Most of them also reported worsening in their speech after the onset of paralysis.

Interviews accomplished 24 months after surgery provided the following results: two patients (6.1 percent) were enthusiastic about the procedure, 10 patients (30.3 percent) were satisfied, 15 patients (45.4 percent) were mildly satisfied, and six patients (18.2 percent) were unsatisfied. Only five patients (15.2 percent) reported improvement during nasal inspiration. Twenty-six patients (78.8 percent) reported improvement in involuntarily cheek biting while chewing. Sixteen patients (48.9 percent) felt their speech ability had improved.

One-way analysis of variance was performed to investigate whether the final subjective satisfaction was different depending on the results observed on the Terzis and Noah scale. Results showed that subjective satisfaction differed depending on the final result, according to the Terzis scale (analysis of variance, $p < 0.05$). Specifically, satisfaction was correlated with the final results on the Terzis and Noah scale, as confirmed by the Spearman rank order correlation coefficient ($r = 0.757$).

The Doppler signal was recorded during the 5 days immediately after the operation for all patients but one, in whom the signal during the fifth day was lost. This patient had the lowest final grade in the series (grade I). No flaps were removed, although flap viability cannot be guaranteed due to the low reliability of external Doppler flow in detecting venous signals (Table 3).

## DISCUSSION

In 1998, Harii et al. proposed a new surgical technique to harvest the latissimus dorsi flap.[8] In adult patients, 15 to 16 cm of the dorsal nerve are harvested via a proximal dissection of the thoracodorsal nerve until its origin from the posterior chorda of the brachial plexus and the distal dissection of the muscle parenchyma. This length is suitable to anastomose the nerve to one or more branches of the contralateral facial nerve for the musculus zygomaticus major. This surgical step is essential to ensure that the correct stimulus is used, as the nerve branches for that muscle are invariably involved in smiling. During the surgical procedure, the selected branch of the facial nerve is evaluated by electrostimulation and on an anatomical basis. Nevertheless, in two cases, we observed the need for the patient to partially contract the contralateral eye to activate the flap, most likely because a part of the donor nerve fibers destined to the orbicularis oculi.[12] In two other cases, the patients contracted the transplanted muscle more effectively during the kissing movement than during smiling; however, a more convincing interpretation is that part of the donor fibers was delegated to the innervation of the orbicularis oris. The best way to try to avoid that problem is to proceed medially with the dissection. On the other hand, that maneuver may lead to branches that are too thin to be anastomosed successfully. The solution to the problem, therefore, may be difficult.

After analyzing the patient videos, we continued to consider a spontaneous smile more aesthetically pleasing than a voluntary one, as it generally happens in the normal population. This suggests that the activation of the transplanted muscle occurs both via an emotional stimulus and via a voluntary action.

Interviews showed differences between the grading system score and the patient's perception of results. In most cases, patients were less enthusiastic than the panel.

Single-stage facial reanimation has been proposed to reduce the time required for treatment and recovery.[13–20] The single-stage procedure involves one nerve anastomosis instead of two, as required by the two-stage technique with nerve cross-face grafting. Theoretically, this would guarantee the passage of a larger number of nerve fibers, though results are no better than those of most two-stage techniques.[21]

The scientific literature reports excessive bulk in 24.4 percent of patients who undergo facial reanimation with microvascular flaps.[1] In this study, only five of 33 patients (15.2 percent) complained of excessive bulk. To avoid excessive bulk, it is critical to obtain a thoracodorsal nerve graft that is at least 15 cm long and to harvest a very distal portion of the latissimus dorsi where it is particularly thin.

Revision of flap tension was necessary in 18.2 percent of cases in our study. This incidence may have been reduced by a surgeon better skilled at finding the "correct" tension positioning for the transplanted muscle. The necessity of resetting the flap position was demonstrated in a series of ancillary procedures, including eyebrow suspension, revision of the nasal groove, and correction of residual eyelid insufficiency, which were required to optimize the surgical results.[1]

For the two children in the series, we avoided making even the smallest incision into the facial vessels by isolating and sectioning them from the nasolabial fold via a preauricular incision prolonged inferiorly and posteriorly to the earlobe.[22] In this fashion, we were able to rotate the vessels laterally and to anastomose them to the thoracodorsal vessels.

Although the House-Brackmann scale is universally utilized to classify facial paralysis, most authors find it unsuitable for facial reanimation patients.[23] In our opinion, the best classification system is the one proposed by Terzis and Noah,[11] because of its ease of use and its utility in evaluating the two most important endpoints of facial reanimation: symmetry at rest and quality of smiling.

Patients do not experience any particular deficit associated with the donor site, according to data present in the scientific literature about latissimus dorsi flap harvesting.[24] That has to be compared with a similar absence of deficit associated with the harvesting of the most utilized free flaps in facial reanimation, such as the gracilis and pectoralis minor.[25] Among two-stage procedures, the deficit of sural nerve grafting may not be neglected.[26]

## CONCLUSIONS

In the present study, single-stage facial reanimation with a microsurgical latissimus dorsi flap achieved morphofunctional results similar to those obtained with classic two-stage techniques. In addition, the procedure spared our patients the deficit associated with sural nerve grafting and reduced the time to recovery.

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