Nerve Sources for Facial Reanimation With Muscle Transplant in Patients With Unilateral Facial Palsy

Clinical Analysis of 3 Techniques

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Abstract: Ninety-one patients with long-standing unilateral facial palsy and submitted to reanimation of the face with muscle transplant were divided into 3 nonrandomized groups: group I: 2-stage facial reanimation, cross face followed by gracilis muscle transplant, 58 patients; group II: 1-stage reanimation with latissimus dorsi muscle transplant, 11 patients (a branch of the facial nerve on the nonparalyzed side of the face was used as the nerve source for reanimation in groups I and II); group III: 1-stage reanimation with gracilis muscle transplant and neural coaptation of the respective nerve and the ipsilateral masseteric branch of the trigeminal nerve, 22 patients. No microvascular complications were observed. The average interval between surgery and initial muscle contractions was 11.1 months, 7.2 months, and 3.7 months in group I, group II, and group III, respectively. The quality (intensity and shape) of the smile, voluntary or involuntary, obtained on the reanimated side in relation to the unaffected side was considered good or excellent in 53.4%, 54.5%, and 86.3% of the patients in groups I, II, and III, respectively. In group I, the average age of the patients with excellent or good results (19.8 + 10.5 years) was significantly lower than that of the patients with fair or poor results or absence of movement (36.5 + 13.3 years). The smile was considered emotional or involuntary in 34% of the patients in group I and 45% in group II. Most of the patients in each group were only able to produce "voluntary smiles". Crossed synkinesis with lip puckering was observed in 48% of the patients in group I and 90% in group II. The results obtained with 1-stage facial reanimation with masseteric nerve were more uniform and predictable than those obtained with the other techniques evaluated in this study.

Key Words: facial palsy reanimation, muscle transplants

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Muscle transplant for treating longstanding facial palsy was introduced by Harii[1] in 1979. At that time, the procedure was performed in 2 surgical stages: cross-facial sural nerve graft sutured to the buccal branch of the facial nerve of the nonparalyzed hemiface in the first stage, followed by microsurgical transplant of the gracilis muscle some months later.

Increased anatomic knowledge broadened the options of muscle tissue used in facial reanimation. In 1988, Harii et al[2] described the use of the latissimus dorsi muscle, which, because of the length of its nerve, did away with interposition cross-facial nerve grafting and allowed for a 1-stage surgical procedure.

The technical variations reported by different authors[3–6] do not change the fundamental aspect of the facial reanimation procedure, which is a free muscle flap positioned on the paralyzed hemiface and reinnervated by the contralateral facial nerve.

In 1995, Zuker et al[7] successfully used the nerve of the masseter muscle (branch of the trigeminal nerve) and the gracilis muscle on both sides in the treatment of Moebius syndrome. Although used in patients who presented with bilateral facial palsy, the results suggested that this technique could be an option for treating unilateral facial paralysis as well.

Literature has shown the effectiveness of these procedures in producing muscle contractions in the paralyzed face but lacks sufficient comparative studies. The objective of this study is to evaluate and compare movements of the middle third of the face obtained with 3 muscle transplant techniques used in patients presenting with unilateral facial palsy.

PATIENTS AND METHODS

Between 1996 and 2005, 91 patients with longstanding unilateral facial palsy were submitted to facial reanimation with muscle transplant. These patients were divided into 3 nonrandomized groups, according to the reanimation technique used: group I: 58 patients submitted to 2-stage facial reanimation; cross-facial nerve graft in the first and microsurgical transplant of gracilis muscle in the second; group II: 11 patients submitted to 1-stage facial reanimation with latissimus dorsi muscle transplant and direct coaptation of the respective nerve and a branch of the facial nerve on the unaffected side; group III: 22 patients submitted to 1-stage facial reanimation with gracilis muscle transplant and direct

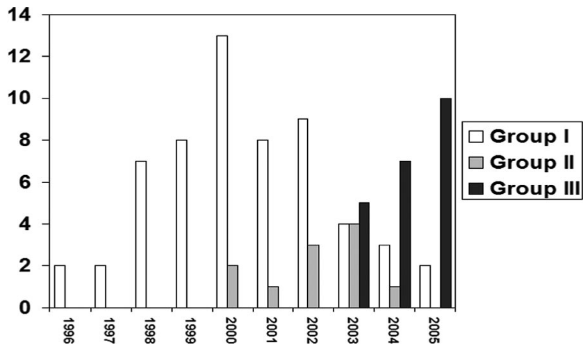

FIGURE 1. Distribution of the number and types of procedures by year.

coaptation to the branch of the trigeminal nerve leading to the masseter muscle of the paralyzed hemiface.

Two patients in group I presented with partial facial palsy affecting mostly the mouth. All the other patients presented with complete hemifacial paralysis. Figure 1 shows the distribution of cases in each group by the year the procedures were performed.

Patient age, sex, length of paralysis, and follow-up after muscle transplant in each group are shown in Table 1.

The same surgical team operated on all the patients. Dissection and preparation of the paralyzed side of the face, the insertion technique, and muscle suturing were similar in each group. The vascular sutures and coaptations were performed with a microsurgical technique using interrupted nylon 10-0 sutures. In all cases, the recipient vessels were the facial artery and vein of the reconstructed side.

In group I, the incision on the nonparalyzed hemiface was made along the path of the anterior border of the parotid gland. In group II, the exact location of the incision on the unaffected hemiface depended on the length of the thoracodorsal nerve, which extended a maximum of 2 cm from the contralateral nasolabial fold. In these 2 groups, the facial nerve branches were selected using electrical stimulation to find the branch that produced movement most similar to the smile. In Group III, the masseteric nerve was identified on the posterior border of the masseter muscle, superior to the parotid duct.

All patients were photographed and filmed pre- and postoperatively. While being filmed, the patients were asked to make voluntary facial movements, such as puckering their lips, smiling and smiling while clenching their teeth. They were also stimulated to laugh and answer questions. The pictures and videos recorded were analyzed by the team that performed the surgical procedures.

RESULTS

No microvascular complications were observed in this clinical study. Four patients in group I were reoperated within 24 hours of muscle transplant for hematoma on the paralyzed hemiface. Three patients in group III developed salivary fistula within the first few days. In 2 patients, the fistula spontaneously closed, and in 1 patient surgical intervention was necessary to stitch the parotid gland. No significant complaints were registered or complications observed with respect to muscle flap donor sites.

In group I, the first contractions after muscle flap transfer were observed from 6 to 15 months (mean: 11.1 months) postoperatively, 6 to 9 months (mean: 7.2 months) in group II, and 3 to 6 months (mean: 3.7 months) in group III.

The smile achieved was graded based on intensity and shape, without consideration of motivation (voluntary or emotional smile):

- Absence of movement
- Poor: muscle contraction visible without movement of the modiolus
- Fair: movement of the modiolus present but not enough to form a smile
- Good: adequate smile shape but asymmetric with the nonparalyzed side
- Excellent: symmetrical smile (shape and intensity)

These results are shown in Table 2. In group I, 53.4% of the patients received a good/excellent evaluation, as well as 54.5% in group II and 86.3% in group III.

The patients of Group I were subdivided into 2 groups:

- Group Ia: patients with excellent or good results
- Group Ib: patients with fair or poor results or absence of movement.

The average age difference of the patients between the 2 subgroups was statistically significant. The length of paralysis was not considered in the comparison between the groups and subgroups, since it was almost always proportional to the age of the patient. There were no differences related to the sex of the patients (Table 3). Due to the small number of cases in groups II and III, a statistical analysis similar to that of group I could not be performed.

The motivation for the smile was also identified. It was considered voluntary when movement occurred when the

TABLE 1. Demographics of Each Group

	Group I	Group II	Group III
n	58	11	22
Age (average)	5–63 years (28.6 years)	10–70 years (41.9 years)	9–58 years (26.5 years)
Sex	16 M:42 F	4 M:7 F	9 M:13 F
Length of paralysis (average)	2–33 years (11.3 years)	3–11 years (6.2 years)	2–18 years (7.2 years)
Follow-up (average)	3–8 years (5.1 years)	3–6 years (4.2 years)	1–3 years (1.8 months)

TABLE 2. Intensity and Shape of the Voluntary or Involuntary Smile After Facial Reanimation

	n	Absent	Poor	Fair	Good	Excellent
Group I	58	4	10	13	24	7
Group II	11	1	1	3	5	1
Group III	22	0	0	3	6	13

TABLE 3. Demographics of Subgroups Ia and Ib

Group	n	Age (Range)	Average*	St. Deviation	Females	Males
Ia	31	5–46 years	19.8	10.5	22	9
Ib	27	7–63 years	36.5	13.3	20	7

*$P < 0.05$ (Student *t* test).

TABLE 4. Motivation for Contraction of the Muscle Flap

	Group I 58 Cases	Group II 11 Cases	Group III 22 Cases
Voluntary	54 (93%)	10 (90%)	22 (100%)
Emotional	20 (34%)	6 (45%)	0
Crossed synkinesis with eyelid closure	2 (3.4%)	0	0
Crossed synkinesis with lip puckering	28 (48%)	10 (90%)	0

patients were asked to smile, show their teeth, or simulate chewing. When movement occurred while speaking or smiling naturally, it was considered involuntary or emotional. Contractions of the muscle flap induced by movements on the unaffected side (synkineses) other than the smile were observed. The results in each group are shown in Table 4.

In every group, the patients developed voluntary control of muscle flap contractions. The rates of recovery of emotional movements (spontaneous smile) were 34% and 45% in groups I and II, respectively (Figs. 2 and 3). All patients with emotional movements (involuntary) were able to reproduce the same movements on command. On the other hand, not all patients with voluntary control of the muscle flap were able to reproduce the same movement during speech or spontaneous laughter.

Contraction of the orbicularis oris on the nonparalyzed side, together with the contraction of the muscle transplant on the paralyzed side, was characterized as "crossed synkinesis." Another type of crossed synkinesis observed in 2 patients of group I was contraction of the gracilis muscle, together with eyelid closure on the unaffected side.

In group III, contraction of the muscle transplant was induced by clenching of the teeth. Only 1 patient in this group complained of contractions of the transplanted muscle during mastication, and no patients complained of drooling. Figure 4 shows static and dynamic (voluntary) facial symmetry achieved in a patient of group III.

DISCUSSION

Muscle transplants are the main option for reanimation of the middle third of the face in longstanding facial paralysis. Although the clinical benefits may be demonstrated with both subjective and objective methods of evaluation, the rates of satisfaction are not directly proportional to the strength and direction of the movements produced.[8]

In a previous study,[8] we observed that subjective analysis of results demonstrates at least 3 different points of view: those of the surgeon, the patient, and the independent lay observer. To minimize conflicting interpretations of the result of one patient, combining objective and subjective criteria for evaluating facial reanimation, we defined parameters for grading the shape and intensity of the smile. The results of this study are consistent with those published by Bae et al,[9] which reported a wider range of commissure excursion after gracilis muscle transplantation for facial paralysis using the motor nerve to the masseter nerve when compared with cross-face nerve graft.

The objective system for evaluating facial paralysis proposed by Frey et al[10] is based on a simple but brilliant concept that allows for simultaneous comparison of both sides of the face. However, its accuracy in evaluating real emotional and spontaneous movements is debatable, since they are associated with a change in body language and with movement of the head in relation to the trunk, which affect

FIGURE 2. Patient in group I (pre- and postoperative view).

FIGURE 3. Patient in group II (pre- and postoperative view).

the posture necessary for us to observe the 2 sides of the face at the same time.

Some of the patients submitted to facial reanimation were able to produce a "nice" smile, symmetrical in shape and intensity, on command. These same patients, however, presented different degrees of asymmetry when stimulated to laugh spontaneously. Based on this fact, we decided to evaluate voluntary and involuntary movements separately.

One argument for using the contralateral facial nerve is the fact that it is the only cranial nerve capable of inducing emotional movements. Yet it was observed in this study that only 34% of patients submitted to 2-stage facial reanimation and 45% of patients submitted to 1-stage reanimation with latissimus dorsi flap developed spontaneous movement of the transplanted muscle in smiling. Rayment et al[11] also reported difficulties in achieving spontaneous smiles in patients submitted to cross-facial nerve transplants.

Although the trigeminal nerve does not induce emotional movements, with time, the patients may achieve some degree of automaticity of movements since mastication and smiling are not completely conflicting functions. The first contractions in this group were confirmed after the third postoperative month, a period much shorter than that needed for innervation in group I and II. The distance between the nerve source and muscle transplant is longer in 2-stage facial reanimation than in cases of 1-stage facial reanimation with ipsilateral masseteric nerve.

Facial expressions are determined by electrical impulses generated in the brain, which are sent to the mimic muscles through the different extratemporal branches of the facial nerve. This neuromuscular organization is complex. At least 10 muscles participate in the labial dynamic during smiling, speech, and swallowing. Additionally, anatomic variations have been described.[12,13] The nerve fibers that conduct electrical impulses to each of these muscles may have different paths. There is no specific facial nerve branch for "smiling."

A combination of the simultaneous contraction and relaxation of muscles around the mouth determines the shape of a smile. The lips are pulled into a smile by the majority of these muscles. Contraction of the orbicularis oris results in lip closure during mastication and puckering and opposes the

FIGURE 4. Patient in group III (pre- and postoperative view).

action of the agonist muscles. Thus, this muscle is the natural antagonist of the smile.

Of the 5 main branches of the facial nerve, 2 are directly involved in the smile. The buccal and marginal branches send fibers both to the agonists and to their natural antagonist, the orbicularis oris. The agonists receive the branches originating closer to the facial nerve trunk. Because the orbicularis oris muscle is closer to the midline, it receives the fibers from the more distal branches of the facial nerve.

In 2-stage facial reanimation, the length of the sural nerve allows it to reach the facial nerve branch as it leaves the parotid gland on the unaffected side of the face. In this region, the quantity of fibers to the agonists is proportionally greater when compared with the quantity of fibers to the antagonist. In 1-stage reanimation, the thoracodorsal nerve is long enough to cross the midline but is only capable of reaching the most distal branches of the facial nerve, near the nasolabial fold. In this region, the majority of the fibers connect to the antagonist muscle. This explains the greater intensity of crossed synkinesis in the patients submitted to reconstruction with latissimus dorsi muscle when compared with 2-stage reanimation.

In all the patients submitted to facial reanimation using the facial nerve branch of the nonparalyzed side, when asked to pucker their lips or while speaking, we observed different degrees of crossed synkinesis with the transplanted muscle, reducing the naturalness of facial expressions.

In our study, we also identified 2 cases where contraction of the transplanted muscle was induced by closure of the eyelids on the nonparalyzed side of the face (group I). This phenomenon demonstrates that the method for selecting the facial nerve branch is not without flaws. Contraction of the muscle flap, together with contralateral eyelid closure or pursing of the lips, does not occur when the masseteric branch is used.

In patients presenting with incomplete facial palsy, surgical access to the masseteric branch may result in lesion of branches with preserved function, more precisely, the zygomatic and temporal branch. Early salivary fistula is also a possible complication of this technique.

Secondary interventions to reinsert the muscle flap at the nasolabial fold or for any other reason may put the nerve that crosses the midline at risk. In these cases, the masseteric branch that does not cross the midline of the face and is hidden under the muscle is relatively protected.

Because of the different information and signals transmitted by the fibers of the facial nerve, such as proprioception, muscle tonus, voluntary movements, and reflexes, in addition to emotional expressions, the results of facial reanimation using this nerve are inconsistent and the rehabilitation process is complex. On the other hand, when the masseteric nerve is used in facial reanimation, it is easily understood by the patient that clenching the teeth produces a "voluntary smile."

All 3 techniques were considered successful from a microvascular standpoint, since there were no losses. Although the individual characteristics of each case that determine the success or failure of the method used in facial reanimation should be researched in more detail, it can be said that, in this clinical study, the best results of 2-stage facial reanimation with gracilis muscle were observed in the younger patients, particularly in those younger than 20 years of age. Finally, after comparing the 3 techniques studied, we found that 1-stage unilateral facial reanimation with gracilis muscle innervated by the motor nerve to the masseter produced more predictable and consistent results.

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