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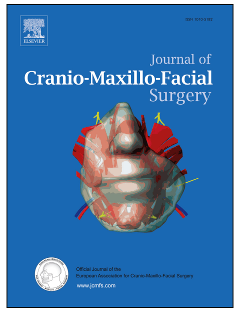

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Abstract

Recent facial paralyses, in which fibrillations of the mimetic muscles are still detectable by electromyography (EMG), allow facial reanimation based on giving new neural stimuli to musculature. However, if more time has elapsed, mimetic muscles can undergo irreversible atrophy, and providing a new neural stimulus is simply not effective. In these cases function is provided by transferring free flaps into the face or transposing masticatory muscles to reinstitute major movements, such as eyelid closure and smiling.

In a small number of cases, patients affected by paralysis are referred late — more than 18 months after onset. In these cases, reinnervating the musculature carries a high risk of failure because some or all of the mimetic muscles may atrophy irreversibly while axonal ingrowth is taking place place. A mixed reanimation technique to address this involves a neurorrhaphy between the masseteric nerve and a facial nerve branch for the orbicularis oculi, to ensure a stronger innervation to that muscle, associated with the transposition of the temporalis muscle to the nasiolabial sulcus. This gives good symmetry in the rest of the midface, while smiling movement is achievable, but not guaranteed. This one-time facial reanimation is particularly indicated for those who refuse major free-flap surgery or when that may be risky, as in previously operated and irradiated fields. More extensive procedures based on utilizing a free flap to recover smiling, while adding a cross-face nerve graft to restore blinking, may be proposed for motivated patients.

Between 2010 and 2015, five patients affected by complete unilateral facial palsy underwent this technique in the Maxillofacial Surgery Department, San Paolo Hospital (Milan, Italy).

Symmetry of the middle-third of the face at rest and recovery of smiling was quite good. Complete voluntary eyelid closure was obtained in all cases.

Combining temporalis flap rotation and a masseteric-to-orbicularis-oculi-facial-nerve branch neurorrhaphy seems to be a valid solution for those medium-term referred patients.

Keywords

facial palsy, facial reanimation, recent facial paralysis, mimetic muscle fibrillations

Introduction

Facial paralysis requiring modern reanimation techniques can be subdivided into recent and long-standing (Biglioli, 2015a; Biglioli, 2015b).

Facial reanimation for recent paralysis is based on restoration of neural stimulus to the mimetic musculature. In general, this procedure can be performed up to 18–24 months after the onset of paralysis, when fibrillations of the musculature are still detectable by electromyography (EMG). The sooner the surgery is undertaken, the better the re-innervation is likely to be. After 24 months, and often sooner, muscles undergo irreversible atrophy, and providing a new neural stimulus is simply not effective. Thus, if fibrillations are not present on EMG, long-standing facial reanimation techniques must be used: these are based on transferring free flaps into the face or transposing masticatory muscles to reinstitute major movements, such as eyelid closure and smiling.

If the patient is referred to the reconstructive surgeon late — more than 18 months after the onset of paralysis — and fibrillations are still present, reinnervating the mimetic musculature carries a high risk of failure because some or all of the mimetic muscles may atrophy irreversibly while axonal ingrowth is taking place. The decision to apply a long-standing facial technique is controversial because it implies renouncing the neurotization of mimetic muscles that may still be recoverable.

In such cases, a mixed approach is taken involving both a recent paralysis facial reanimation technique and a long-standing paralysis one — a neurorrhaphy between the masseteric nerve and a facial nerve branch for the orbicularis oculi, plus a transposition of the temporalis muscle to the nasolabial sulcus. In comparison with the classical masseteric-to-facial-nerve trunk (in this case, two neurorrhaphies are required because of the use of an interpositional nerve graft), the aim of a direct neurorrhaphy of the masseteric nerve to the facial nerve branch for the orbicularis oculi is to reduce re-innervation time and to provide more axonal ingrowth for the orbicularis oculi. Middle-third static symmetry can be achieved by temporalis muscle transposition, with the concomitant goal of at least partially restoring smiling.

This one-time facial reanimation is particularly indicated for those who refuse major free-flap surgery or when that may be risky, as in cases of previously operated and irradiated fields. More extensive procedures based on utilizing a free flap to recover smiling, plus adding a cross-face nerve graft to restore blinking, may be proposed for motivated patients.

Patients and methods

Surgical technique (Figure1)

A face lift-type incision was extended cranially 8 cm into the temporalis region and caudally into a neck skin crease just inferiorly to the mandibular border, allowing exposure of the middle third of the face, following a subcutaneous plane of dissection. A medial dissection was made to 1 cm over the nasolabial sulcus, where 2/0 nylon stitches were positioned and tested by gentle pulling to ensure the formation of a pleasant nasolabial sulcus. (Submandibular incision may be avoided by placing an incision correspondingly to the nasolabial sulcus, reaching the coronoid process through the buccal fat pad.)

Next, just in front of the parotid gland, the masseter fibers were teased apart 1 cm below the zygomatic arch until the masseteric nerve was identified, ~2 cm beneath the muscle surface. This appeared white in a brown/red context, running at a 45° angle downward and medially into the muscle. The nerve was traced distally for 2.5–3 cm, where it was cut, which allowed for its subsequent superficial turning and an easier neurorrhaphy. Once the masseteric nerve was gently pulled apart, the lower insertions of the temporalis muscle fibres were identified deeper into the masseter. The coronoid process was osteotomised by piezo surgery to rotate the lower extremity of the temporalis muscle anteriorly and inferiorly by pulling the bone, as well as to better detach the temporalis tendon bony insertions.

Simultaneously, a 6 cm × 4 cm fascia lata graft was harvested and transferred into the facial surgical field, where it was stitched to the temporalis tendon. The opposite pole of the fascia was divided into 3/4 strips and secured to the previously placed stitches while paying attention to gently overcorrecting the position of the nasolabial sulcus. Addition of the fascia lata allows a better distribution of temporalis muscle action over the entire nasolabial sulcus, and yields a more pleasing result.

Next, a facial nerve branch, directed anatomically towards the eye, was identified over the masseter muscle. If the branch appeared too thin, it was traced proximally until it joined other branches with the same course, leading to the main one, directed to the orbicularis oculi muscle. The identified branch was severed proximally while paying attention to the maintenance of a sufficient length to make a direct neurorrhaphy with the masseteric nerve without turning it at an acute angle, because that could theoretically represent a mechanical stop for subsequent axonal nerve regrowth. The epineural neurorrhaphy was accomplished with 11/0 polypropylene stitches, and the gentle curve of the facial nerve branch was stabilised with fibrin glue aspersion.

Accurate haemostasis, rinsing, and plane suturing completed the surgery.

Patients and Methods

Between 2010 and 2015, five patients affected by complete unilateral facial palsy — grade VI according to the House–Brackmann classification (House and Brackmann, 1985) — underwent surgical treatment in the Maxillofacial Surgery Department, San Paolo Hospital (Milan, Italy) to correct middle-third symmetry of the face and orbicularis oculi muscle movement (Figures 2 and 3; Video1).

All patients had developed unilateral facial palsy after skull-base surgery. They came to our attention after a mean of 23 months after the onset of the facial palsy (range 19–27 months).

All patients underwent a preoperative clinical and neurophysiological examination to assess the presence of muscle fibrillations in both the mimetic muscles and the masseter muscle by electromyography (EMG). Needle EMG revealed that consistent fibrillations of the main facial motor units (orbicularis oculi and orbicularis oris) were still present, while mild fibrillations could also be detected for the zygomatic muscle complex. The trigeminal motor component was also tested clinically by palpation of the masseteric muscle while asking the patients to clench their teeth. EMG data confirmed the findings.

The senior author (FB) performed all surgeries. All patients were operated on according to the previously described technique. They all received postoperative physiotherapy, working directly with a physiotherapist (SC). This physiotherapy had several goals:

1. To help patients understand and ‘feel’ the movement, enabling them to learn the optimal stimulus to improve it and use it often.

The patients needed to learn to recruit each motor unit and feel the amount and the direction of the movement for themselves. To these ends, the therapist proposed perception exercises and provided tactile stimuli, pressers, and kinaesthetic inputs.

The therapist moved the key points of the face, such as the mouth corners, in different directions and with changing amplitudes and invited patients to reproduce the same movement, clench their teeth, and modulate the muscular tone.

The ability to recognise the different spacing between the teeth was also emphasised; patients were invited to approach the teeth and to try and feel the movement in the cheeks.

2. To symmetrise smiling with the contralateral side.

Therapy was targeted at helping patients recognise the difference between the left half of the face and the right half under a resting condition and while smiling. Patients performed several recognition exercises using different lengths and surfaces. During voluntary movements, the stronger side of the face must not prevail over the other side, because this could inhibit the correct recruiting of regenerated fibres.

We also tried to sensitise patients towards correct timing in moving the mouth corners. Patients learned to automatically modulate the movements, depending on the intensity, when asked to express different moods, with the final elevation movement of the cheek depending on the expression of the particular emotion.

3. To reduce synkinesis as much as possible.

The rehabilitation process was aimed at controlling the establishment of synkinesis, while avoiding electrostimulation (Targan et al., 2000) and motor facilitation techniques. Patients were guided through a range of exercises for the eye and mouth, and were also assisted in modulating the intensity of the effort, according to the reinnervation process.

It must be remembered that the brain considers movement as a group of finalised actions (Denlinger et al., 2008); thus, it is effective for patients to perform actions that imitate facial expressions by starting with the creation of a motor image before initiating the actions (Vanswearingen, 2008).

Patients were invited to imagine the actions by imagining the related emotion. With functional requests (look at something, peek at something, smile), patients were trained to coordinate the closing of the eyes and to perform this action independently from the movement of the mouth, modulating the recruitment of masticatory muscles. Through these rehabilitative strategies, patients were guided to perform qualitative recruitment, while trying to decrease synkinesis.

Patients were asked to inform the medical team when they recognised their first mimetic muscle contraction after the surgery. From that moment, each patient underwent periodic clinical evaluations every 6 months.

A final assessment, 12 months after surgery, was performed by a team composed of a surgeon and a physiotherapist not involved in the treatment. They observed each patient and rated photos and videos for symmetry at rest and during movements according to Terzis and Noah (Terzis and Noah, 1997) and for synkinetic assessments according to Terzis and Karypidis (Terzis and Karypidis, 2012).

Results

The immediate postoperative period was uneventful in all cases. Patients reached grades III–IV (median IV), with almost complete movement both for smiling and eyelid closure (Terzis and Noah, 1997). Synkinesis was present in all cases, which was classified as ‘I’ (mild, slight synkinesis) in one case and ‘II’ (moderate to obvious, but not disfiguring) in the other four cases according to Terzis and Karypidis (median II) (Terzis and Karypidis, 2012).

In all patients, a mild stimulus produced smiling without evident eyelid closure, while a stronger stimulus allowed closure of the eyelids, always associated with synkinetic smiling. (Figures 4–6; Video 2)

Symmetry of the middle third of the face at rest was optimal, and complete voluntary eyelid closure was achieved in all patients. None of them recovered the ability to blink, because of the lack of a spontaneous stimulus on the orbicularis oculi muscle. As a result, patients were instructed to voluntarily close their eyelids at least once per hour. No patient needed to use artificial eye lubricants or drops at 12 months after surgery.

During the first month after surgery, all patients needed to clench their teeth to achieve both eyelid closure and smiling. After that early period, they had only to think about a stimulus (not clenching their teeth) to produce the movements. After 4–6 months of continued physiotherapy exercises, they were able to smile automatically in appropriate situations (without thinking about doing it).

Laughing and smiling became emotionally linked in response to a strong humorous stimulus, such as a joke, only in two cases (Video 3). This was because of the absence of the facial nerve stimulus. In fact, both the masseteric nerve and deep temporalis nerves are branches of the third trigeminus division (Biglioli et al., 2012a; Biglioli et al., 2012b; Peng and Azizzadeh, 2015) (Table 1).

Discussion

The timing of repair is key when treating facial paralysis because stronger axonal regeneration and better mimetic muscle recovery will occur if surgery is undertaken sooner (Biglioli, 2015a). It has been observed that a muscle innervated by the paralytic nerve becomes irreversibly atrophic because of fibro-adipose metaplasia, which is evident mainly within 18–24 months. In such cases, it is not worth providing a new neural impulse to the mimetic musculature, and it is better to substitute its function with a free-flap transposition (Allevi et al., 2015; Biglioli et al., 2009; Harii et al., 1998; Sforza et al., 2015), masticatory musculature rotation (Bos et al., 2016; Frey et al., 2004), or other techniques (Biglioli et al., 2014a; Amer et al., 2011; Biglioli, 2015b; Catalano et al., 1995; Hontanilla, 2001; Malik et al., 2002; May, 1987; Tan et al., 2013). Accordingly, immediate facial nerve repair is best performed contemporaneously with nerve severing when the occurrence of the latter has been ascertained (Biglioli et al., 2014b; Biglioli et al., 2016; Lee et al., 2015; Owusu et al., 2016).

If a facial nerve is not available as a motor source, an alternative nerve must be chosen. To supply a new neural stimulus to the paralysed muscles, preferred alternatives are the masseteric nerve, the deep temporalis nerves, or part of the hypoglossal nerve

(Biglioli et al., 2012c; Biglioli et al., 2016; Hontanilla et al., 2014; Hontanilla and Marre, 2015; Terzis and Tzafetta, 2009). These motor nerves provide a quantitative stimulus, according to Biglioli (Biglioli, 2015a). The natural, qualitative stimulus is given only by the homolateral or contralateral facial nerves (which may be used by cross-face nerve grafting) (Gousheh and Arasteh, 2011; Lee et al., 2008; Terzis and Karypidis, 2010; Tomita et al., 2010).

Quantitative and qualitative stimuli are combined in most modern approaches to precocious facial reanimation, in order to obtain the most effective reinnervation together with the recovery of spontaneity in smiling and blinking, and authenticity of mimetic movements (Bianchi et al., 2014; Tomita et al., 2010; Watanabe et al., 2009). The same concept also applies to repairing long-standing facial paralysis (Biglioli et al., 2012; Biglioli et al., 2013).

All patients affected by facial paralysis must be examined with EMG to not only assess the possibility of reactivating the mimetic musculature, but also to map the status of a potential motor donor nerve, such as the masseteric, hypoglossal (maximum 30% of its fibres), deep temporalis, or contralateral facial nerve. In the five cases presented, mimetic muscle fibrillations were detected, but the possibility of the musculature undergoing irreversible atrophy by the time a new neural stimulus arrived via a classical masseteric-to-facial nerve neurorrhaphy was high. Thus, given the asymmetry of the middle third of the face and lack of smiling on one side, and given the impossibility of closing the eyelids on the other side, which were the two main deficits of facial paralysis, it seemed important to concentrate on those two issues to obtain a ‘good’ recovery. The main functional deficit — lack of eyelid closure — was addressed by focusing on the masseteric potential of re-innervating the orbicularis oculi branch. This was achieved by a single neurorrhaphy, instead of two (the masseteric-to-facial nerve requires an interpositional nerve graft with a proximal neurorrhaphy with the masseteric nerve and a distal one with the facial nerve trunk) (Allevi et al., 2014; Biglioli et al., 2017; Codari et al., 2017; Sforza et al., 2012), which reduced the neurotizing time, lowering the chances of muscle atrophy.

The fact that a low-grade stimulus produced smiling, without evident eyelid closure, and that a stronger stimulus (such as clenching the teeth) allowed eyelid closure, albeit with synkinetic smiling, is attributable to the intact neural innervation of the temporalis, which allowed its easy activation even by a bland stimulus.

Postoperative synkinesis was similar to what usually happens for masseteric-to-facial nerve neurorrhaphy — i.e. a mild neural stimulus allowing smiling but without closing the eyelids. A stronger stimulus gives rise to eyelid closure, often synkinetic to a different grade of smiling. The latter is due to the stronger innervation of the musculature in the middle-third of the face compared with the orbicular oculi. Thus, a weaker stimulus activates only the middle-third, without evident contracture of the eyelids.

Rotation of the temporalis muscle is performed with the goal of obtaining a predictable static symmetry, with an acceptable possibility of re-establishing a moderate grade of smiling. In cases in which the smiling movement is not consistent, at least static correction can be obtained. Finally, according to Harii, in cases of insufficient smile recovery, a second reanimation procedure, such as a one-time latissimus free-flap transposition, could be undertaken later (Allevi et al., 2015; Biglioli et al., 2009; Harii et al., 1998).

The temporalis lengthening myoplasty (TLM) procedure (Foirest et al., 2016; Guerreschi and Labbé, 2015a; Guerreschi and Labbé, 2015b; Moubayed et al., 2015) became popular during the last decade, but we preferred the newer variant of McLaughlin's technique (McLaughlin, 1953) proposed by Boahene (Boahene, 2013) because it is less complicated and carries less morbidity than TLM. In our experience, the claimed advantage of obtaining emotional smiling with TLM or the Boahene procedure is similarly seldom achieved. Furthermore, in our experience, use of a fascia lata graft yields superior nasolabial sulcus formation than the direct insertion of the temporalis tendon as suggested for TLM. In contrast, Boahene's procedure allows a reduction in surgery time and, most importantly, morbidity. Finally, exercising with a physiotherapist seems essential to achieving a full functional result from this procedure, enhancing the automaticity of smiling, and reducing synkinetic movements.

CONCLUSIONS

Combining a temporalis flap rotation and a masseteric-to-orbicularis-oculi-facial-nerve-branch neurorrhaphy seems to be a valid solution for medium-term referred patients with fibrillations still present on EMG examination. Orbicularis oculi reanimation and midface symmetry are commonly achieved, while smiling recovery may be suboptimal.

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Captions to illustrations

Figure 1: The temporalis muscle flap is rotated anteriorly to reach the nasolabial sulcus through fascia lata strips (big arrow). The neurorrhaphy between the masseteric nerve and the facial nerve branch for the orbicularis oculi muscle is indicated by a small arrow.

Figure 2: Preoperative image showing mild asymmetry of the face at rest.

Figure 3: Preoperative image showing gross asymmetry of the face during movements.

Figure 4: 12-month postoperative image showing good grade of symmetry of the face at rest.

Figure 5: 12-month postoperative image showing good ability to smile.

Figure 6: 12-month postoperative image showing complete eyelid closure, with synkinetic mild smiling.

Video 1: Facial paralysis grade VI according to HB.

Video 2: Smiling and eyelid closure, 12 months postoperatively.

Video 3: Emotional activation of smiling with partial showing of teeth while watching a funny movie.

Table 1 Demographic, preoperative, and postoperative data for all patients included in the study.

Patient	Age	Sex	Etiology	Preoperative assessment*	Timing of reconstructive surgery	Postoperative symmetry**	Postoperative synkinetic assessment***
E.C.	45	F	Skull base surgery	VI	19	IV	II
R.D.	52	F	Skull base surgery	VI	27	IV	I
F.N.	63	M	Skull base surgery	VI	26	III	II
D.C.	48	F	Skull base surgery	VI	24	IV	II
S.T.	53	M	Skull base surgery	VI	19	III	II

*House-Brackmann classification was used for the preoperative assessment (grade VI — no movements at all for all patients).

**Terzis and Noah classification was used for postoperative assessment of symmetry at rest and during movements (grade III — moderate symmetry and contraction for two patients; grade IV — good symmetry and nearly full contraction for three patients).

***Terzis and Karapidis classification was used for postoperative synkinetic assessment (grade I — slight synkinesis in one patient; grade II — obvious but not disfiguring synkinesis in four patients).