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Masseteric–facial nerve anastomosis for early facial reanimation

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ABSTRACT

Objective: Early repair of facial nerve paralysis when cortical neural input cannot be provided by the facial nerve nucleus, is generally accomplished anastomozing the extracranial stump of the facial nerve to a motor donor nerve. That is generally the hypoglossus, which carries a variable degree of morbidity. The present work aims to demonstrate the effectiveness of the masseteric nerve as donor for early facial reanimation, with the advantage that harvesting is associated with negligible morbidity.
Methods: Between October 2007 and August 2009, 7 patients (2 males, 5 women) with unilateral facial paralysis underwent a masseter–facial nerves anastomosis with an interpositional nerve graft of the great auricular nerve. The interval between the onset of paralysis and surgery ranged from 8 to 48 months (mean 19.2 months). All patients included in the study had signs of facial mimetic muscle fibrillations on electromyography. The degree of preoperative facial nerve dysfunction was grade VI following the House-Brackmann scale for all patients.
Results: At the time of the study, all the patients with a minimum follow-up time of 12 months after the onset of mimetic function had recovered facial animation. Facial muscles showed signs of recovery within 2–9 months, mean 4.8 months, with the restoration of facial symmetry at rest. Facial movements appeared while the patients activated their chewing musculature. Morbidity related to this intervention is only the loss of sensitivity of earlobe and preauricular region.
Conclusion: The present technique seems to be a valid alternative to classical hypoglossal–facial nerve anastomosis because of similar facial nerve recovery and lower morbidity.

1. Introduction

Facial paralysis are distinguished into two main groups according to the presence or absence of facial fibrillations at needle electromyography. Recent paralysis, mainly lasting less than two years (but some of them are older), generally show these signs and are eligible for reactivation of facial nerve anastomosing it to a donor one (early facial reanimation) (Terzis and Tzafetta, 2009). Indeed, when the proximal stump of the seventh cranial nerve cannot be used for anastomosing, the motor stimulus must be accomplished by utilizing another cranial motor nerve.

The contralateral facial nerve, using the technique of cross-face nerve grafting (Smith, 1971; Scaramella and Tobias, 1973), allows recovery of facial nerve mimetic function both under voluntary and emotional stimulus, thus providing the preferred innervation. This technique should be performed when the denervation time is less than 5 months in order to obtain fair results (Frey et al., 2006). A longer waiting time lead to a high percentage of unsuccessful operations. Donor-site sensory deficit in the lower extremity is an additional disadvantage of this procedure. The "babysitter" procedure – a cross-face nerve grafting associated with a partial hypoglossal/accessory spinal–facial nerve anastomosis, was introduced in 1984 by Terzis (1990), to restore facial nerve function when denervation time is more than 6 months (up to 27 months). This procedure allows quick recovery of facial nerve function while cross-face sural nerve grafting is undergoing axonal nerve ingrowth. By the time the distal end of the grafted sural nerve is to be anastomosed to the facial nerve, the facial muscles and neuromuscular junctions have not fallen into irreversible atrophy.

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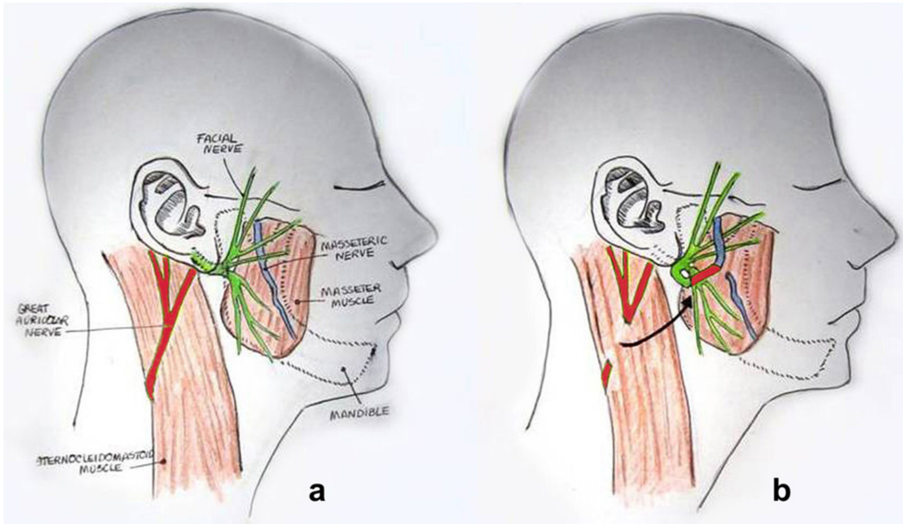

Fig. 1. Drawing of masseter to facial nerve anastomosis. (a) Facial nerve, masseteric nerve and great auricular nerve are identified. (b) 5–6 cm of great auricular nerve is grafted between the proximal end of the masseteric nerve and the main trunk of the extracranial facial nerve.

When neither the contralateral facial nerve or the ipsilateral one are available, because of multiple cranial nerve involvement, Moebius syndrome or the time since the onset of facial paralysis is too long to consider a cross-face nerve graft procedure, an alternative donor motor nerve is needed.

Spinal accessory–facial nerve anastomosis, first performed by Ballance in 1895 (Van der Graf et al., 2008), was the first to be described in literature. Functional downgrading of the sternocleidomastoid and trapezius muscle functions is a major drawback of this technique. Currently this technique is mainly utilized when the hypoglossal nerve is completely or partially damaged as well as when swallowing is already problematic.

The motor roots of the cervical plexus are an alternative but less favourable motor source, indicated only when complex multiple cranial nerve involvement is present (Terzis and Konofaos, 2008).

Currently the most frequently used donor nerve is the hypoglossus, first attempted by Korte (1903) in 1901. Hypoglossal–facial nerve end-to-end anastomosis is considered an effective and reliable technique that gives satisfactory results. Unilateral denervation of the tongue is the most common consequence, leading to tongue atrophy in 50–70% of cases and worsening eating and swallowing ability in 20–45% of cases (Yetiser and Karapinar, 2007). Functional results are typically mass movements of the face and synkinesis associated with extreme tongue movement that are frequently observed. Modification of the anastomosis technique from end-to-end to end-to-side seems to reduce tongue dysfunction, but the success of this modified technique on facial reanimation is still unclear.

In order to reduce the morbidity associated with early facial reanimation while maintaining a high rate of success, the masseteric nerve, branching from the trigeminal nerve, has already been shown to be a reliable alternative. A few reports describe its use for selective facial nerve branch reanimation (Escat and Viela, 1925; Spira, 1978; Bermudez and Nieto, 2004) or for chronic facial reanimation (Zuker et al., 2000).

The new technique describes early reanimation accomplished by anastomosing the masseteric nerve to the entire facial nerve trunk with a great auricular nerve interpositional graft. (Fig. 1).

2. Surgical technique

1:200.000 epinephrine is injected 5 min before surgery subcutaneously into the parotid region along the intended line of the skin incision, which has been marked. This is a face-lift type incision, beginning in the temporal region, passing hidden behind the tragus, under the earlobe and extending into the mastoid region. An antero-inferior skin flap is elevated in order to access the parotid-masseter region.

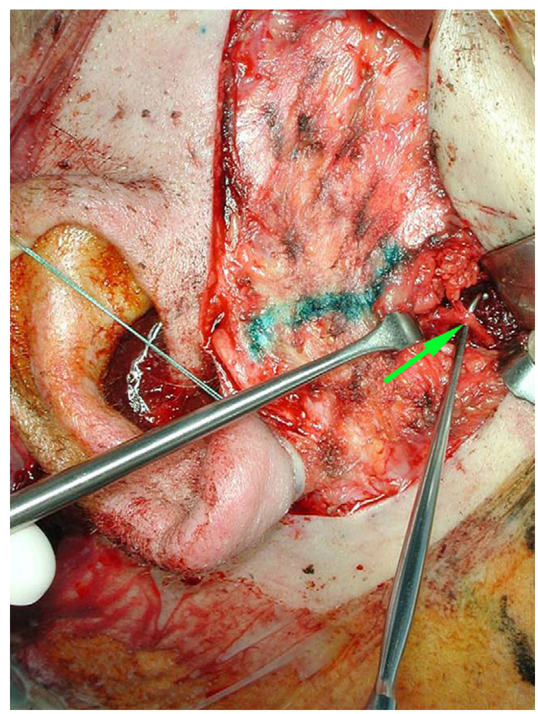

Fig. 2. The masseteric nerve identified into the muscular parenchyma (arrow).

The first nerve to be identified is the great auricular nerve. This is immediately deep to the superficial cervical fascia, 4–5 cm inferior to the earlobe, over the anterior border of the sternocleidomastoid muscle. The nerve is traced inferiorly for few centimetres and superiorly until it enters the parotid gland. 5–6 cm of the main trunk are taken to be used as an interposition nerve graft.

Now the VII nerve is identified at its exit from the styloid foramen by the standard extracranial antegrade technique. All the nerve trunk and first 2 cm of the main branches after the bifurcation are traced. Finally, the masseter motor nerve is identified in the muscle parenchyma (Fig. 2). Surgical landmarks are the zygomatic arch and the posterior border of the masseter muscle. Detaching the muscle insertion to the zygomatic arch is not necessary as the masseteric nerve is really deep at this level. It is best to enter into the muscle 1 cm above the arch and 1 cm medial to the posterior border. The upper and middle branches of the facial nerve may be seen over the masseter surface. These must be spared when dissecting between them. The nerve lies 1.5–2 cm deep to the muscle surface and is made visible by gently dissecting the muscle fibres along their axis (almost vertical). These part easily and the nerve shows up spontaneously.

One or two small collateral branches of the masseteric nerve may be cut when proceeding supero-inferiorly to allow harvesting 2.5/3 cm of nerve trunk.

The facial nerve trunk is now cut at its exit from the styloid foramen and the masseteric nerve is cut distally. Both nerves are rotated to match each other. The few centimetres between their extremities are filled by the interposition graft of the great auricular nerve. This is set backwards in order to lose as few axonal fibres as possible while new fibres are growing through the graft.

Both proximal (masseteric nerve/great auricular nerve) and distal anastomoses (great auricular nerve/facial nerve) are accomplished end-to-end with a few 10-0 epineural stitches surrounded by fibrin glue (Fig. 3).

The parotid fascia is sutured over the anastomoses to provide good vascularity for the graft, and to protect the whole nerve route. Meticulous haemostasis and positioning of suction drainage is important. Finally, a well hidden aesthetic suture ends surgery.

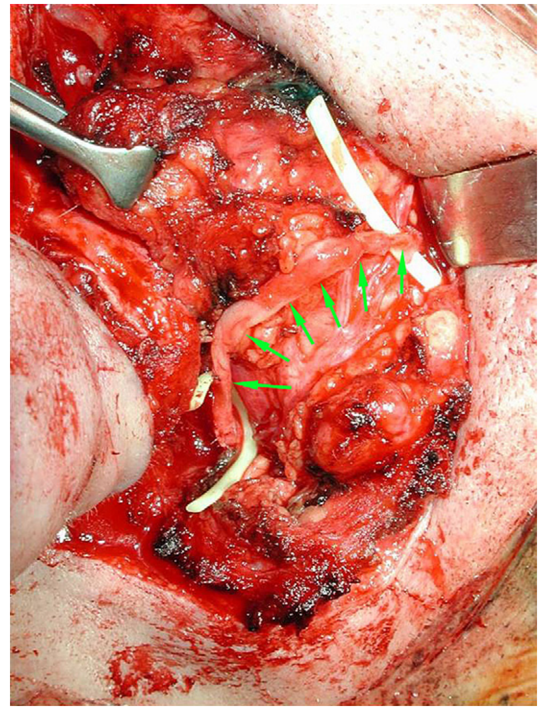

Fig. 3. A tract of great auricular nerve (arrows) grafted between masseteric and facial nerves.

3. Materials and methods

Between October 2007 and August 2009, 7 patients (2 men, 5 women) affected by unilateral complete facial paralysis underwent a masseter–facial nerve anastomosis with a great auricular interpositional nerve graft. The ages of the patients ranged between 23 and 48 years (mean 35.1 years). The time from the onset of the paralysis ranged between 8 and 48 months (mean 19.2 months). Patients operated within 12 months from the onset of paralysis were documented to have the VII nerve transected intraoperatively during previous cranial base surgery. The aetiology was a complication of skull base surgery in 6 cases and a Bell's palsy lasting 18 months in 1 case. All palsies were grade VI on the House-Brackmann scale. Clinical evaluation was complemented by preoperative needle electromyography (EMG) that assessed complete facial nerve and muscle injury in all patients. At the EMG and needle EMG study all patients presented with severe (complete) denervation in the facial nerve territory with lack of motor unit action potential (MUAP) recruitment and nerve trunk inexcitability (direct stimulation at tragus and evaluation of blink reflex responses).

All patients had fibrillations demonstrating mimetic musculature presence despite the length of time since denervation (Terzis and Tzafetta, 2009). Those patients who did not show fibrillations underwent free-flap transposition for facial reanimation because of the extremely low possibility of masseter–facial nerve anastomosis to achieve success. The trigeminal motor component was tested clinically by palpating the temporal region when chewing and by needle EMG in the ipsilateral masseter muscle in order to use it as donor motor nerve.

After surgery, all patients were instructed to call a member of the team at first movements of the face. As soon as the patients called, a clinical evaluation was carried out and the first postoperative EMG was performed.

All patients received postoperative physiotherapy from the time recovery began for one year. Patients were asked to watch themselves on a mirror (bio-feedback) while achieving symmetry at rest, biting and without biting, and while smiling or making grimaces. All movements had to be slow, allowing selective muscle control; patients were taught to gradually reduce the strength of bite necessary to achieve mimetic muscle activation during the rehabilitation period.

Table 1
Results classification (Terzis and Noah, 1997).

5	EXCELLENT	Symmetrical smile with teeth showing, full contraction
4	GOOD	Symmetry, nearly full contraction
3	MODERATE	Moderate symmetry, moderate contraction
2	FAIR	No symmetry, minimal contraction
1	POOR	Deformity, no contraction

Evaluation of facial reanimation was done 12 months after the first clinical signs of mimetic recovery after surgery. All the patients who underwent the surgical operation have this minimum follow-up time at the time of the study. From then on, patients underwent a routine clinical evaluation every three months. At the time of the study, patients underwent clinical examination to assess the symmetry of the face at rest and the quality and quantity of the dynamic recovery. Patients were asked to smile and close their eyes while activating their chewing musculature. The quality of eye closure and mouth corner movement and any synkinesis or mass movement were recorded and studied by one physician and a physiotherapist. Results were classified according to the J. Terzis scale (Terzis and Noah, 1997) (Table 1). Finally, patients were recorded on a video-camera while left in a room alone (to avoid any external influence) watching a funny video, looking for any spontaneous activation of the reanimated hemi-face.

4. Results

The average duration of surgery was 2 h and 15 min. Wound healing and postoperative recovery were uneventful in all patients.

At the time of the study, all the patients operated on had recovered facial mimetic function. Recovery time ranged from 2 to 9 months after surgery, mean 4.8 months.

If we consider orbicularis muscle contraction while activating the chewing muscles complete eyelid closure was achieved in 4 patients and partial closure, with 1–2 mm scleral show, was seen in 3 patients. Before surgery, the mean scleral show was 5.7 mm and the mean eyelid closure improvement was 5 mm. Data related to each patient are shown in the table below (Table 2).

Clinical evaluation showed that the final result of symmetry at rest and dynamic restoration of smile while activating the chewing musculature was excellent in two cases (Figs. 4a–b, 5a–b, 6a–b, 7a–b), good in three cases and adequate in two cases. The only patient with long-lasting paralysis (48 months) was among those two with adequate result at smiling and partial lid closure.

Among all patients light/medium strength activation of the masticatory muscles leads to the movement of the lower two-thirds of the face. This leads to a pleasant full dental smile on observation.

All patients showed synkinesis between the upper and the lower parts of the face on maximal chewing effort.

Partial discrimination of facial movement of the lower two-thirds of the face towards the upper third was possible in all patients by concentrating and modulating the strength of chewing signal.

Table 2
The table explains the data relative to scleral show in 7 patients before and after surgery.

Cases	Scleral show		Improvement (mm)
	Before surgery (mm)	After surgery (mm)	
PZ 1	7	2	5
PZ 2	6	0	6
PZ 3	5	0	5
PZ 4	6	0	6
PZ 5	7	2	5
PZ 6	3	1	2
PZ 7	6	0	6
Mean	**5.7**	**0.7**	**5**

Three patients showed partial activation of the *frontalis* branch of the facial nerve; these patients had the best discriminatory skill within the different branches.

Observing the video of patients watching the funny movie, none of the patients recovered a spontaneous smile. All of them activated only the non-operated side mimetic musculature while laughing spontaneously. So the operated side could be activated only by voluntary stimulus.

One patient reported limited mouth opening during the first 8 postoperative weeks, due to masseter scar formation. Recovery of full opening of the mouth was reached by 3 weeks of physiotherapy. None reported limited strength in chewing. One patient showed thinning of the cheek postoperatively, probably due to masseter muscle atrophy because of denervation. He refused a lipofilling procedure because he felt asymmetry was not significant.

5. Discussion

The first attempts at the use of the masseteric nerve as a donor motor nerve in facial reanimation were done in 1925 by Escat and Viela (1925). There were a few preliminary reports by Spira (1978) and anatomical studies by Brenner and Scholler (Fournier et al., 1997; Brenner and Schoeller, 1998) followed, but no wide clinical series have been published yet.

In 2000 Zuker et al. (2000) popularized the use of the masseter motor nerve as donor source to reinnervate free gracilis flaps in patients affected by Moebius syndrome. Six years later the same authors published a series of 45 gracilis muscle transfers innervated by the masseteric motor nerve in 27 patients affected by Moebius syndrome with excellent morpho-functional results (Manktelow et al., 2006).

In 2004 Bermudez and Nieto (2004) published a case report of masseteric–facial nerve transfer, with anastomosis between the branch of the masseteric nerve to a zygomatic branch of the injured facial nerve. This procedure was suggested as a good alternative for facial reanimation in patients with partial palsies. Initial movement appeared 4 months after surgery and complete recovery was seen 6 months postoperatively.

Fig. 4. (a) Preoperative image of a 48 years old female patient, affected by facial paralysis after acoustic neuroma surgery. Masseteric to facial nerves anastomosis was accomplished 8 months after insetting of paralysis. (b) Appearance of patient at rest 9 months postoperatively (first contraction 4 months after masseteric to facial nerves anastomosis).

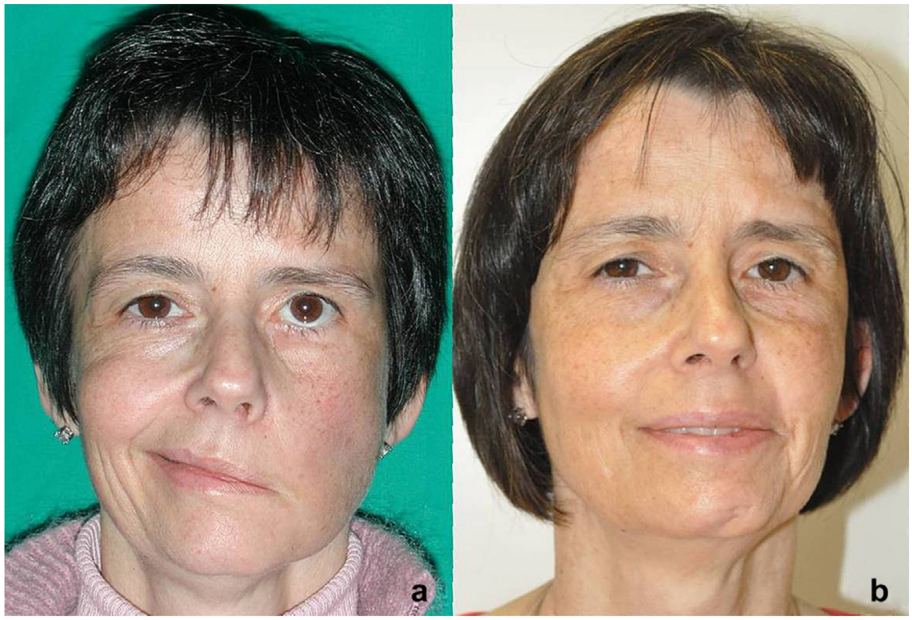

Fig. 5. (a) The attempt to use mimetic musculature preoperatively disfigure the patient. (b) Restoration of smiling is symmetrical 9 months postoperatively.

Fig. 6. (a) Preoperative image of a 40 years old female patient, affected by facial paralysis after acoustic neuroma surgery. Masseteric to facial nerves anastomosis was accomplished 19 months after insetting of paralysis. (b) Partial symmetry of the face at rest 12 months after surgery (first contraction 5 months after masseteric to facial nerves anastomosis).

In the case of complete facial palsy, the distance between the main trunk of the facial nerve and the masseteric nerve might be filled by tracing all facial nerve and its branches running into the parotid gland parenchyma as in case of superficial parotidectomy and aligning it to reach the masseteric nerve stump, but, we feel that this is too traumatic for the nerve itself and we prefer to use a segment of interpositional nerve graft.

The authors believe that the great auricular nerve represents the best choice for grafting as it is available in the same operative field and the subsequent earlobe sensory deficit may be considered a low donor-site morbidity (Biglioli et al., 2002).

The lack of spontaneity of smiling using trigeminal source has been widely reported. Because of this, techniques for reanimation in chronic palsy shifted from a trigeminal motor source, such as the deep temporalis nerve (Harii et al., 1976), to the contralateral facial nerve (Biglioli et al., 2009). Recently Manktelow et al. (2006), studying Moebius patients using masseter donor source, assessed the recovery of spontaneous smile in 89% of patients, at a mean follow up of 4.7 years. Other authors have shown that cortical adaptation to restoration of smiling after free muscle transfer innervated by the masseteric nerve is possible (Lifchez et al., 2005). Faria et al. (2007) suggested that an automatic smiling-like movement may be possible since smiling and chewing are similar functions, even if they have not observed any spontaneity in smiling within the masseter nerve as donor source. A distinction must be made between spontaneous and automatic movement, as

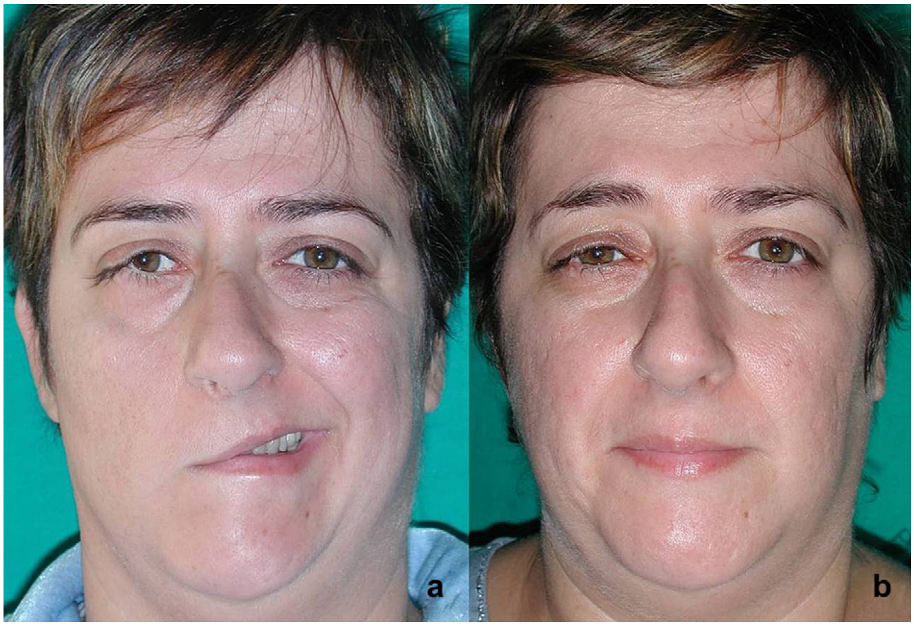

Fig. 7. (a) The attempt to use mimetic musculature preoperatively disfigure the patient. (b) Restoration of smiling is symmetrical 9 months postoperatively.

the latter is accomplished by the patients almost not thinking about "when he wants" to smile. A spontaneous smile is absolutely not voluntary when the persons laugh without "wanting" to. From our video investigation this does not happen when having a trigeminal motor source such as the masseter muscle. Again Manktelow et al. (2006) believe that the ability to smile spontaneously depends on the intensity of early practice. That might be possible in Moebius patients, but it is not seen in our series despite physiotherapy.

All our patients underwent an intensive physiotherapy program. Visual feedback in front of the mirror allows awareness to be gained of the newly acquired motor pathways of the facial muscles, now innervated by trigeminal nerve (masseteric nerve). Patients were taught to achieved symmetry at rest and then to activate their mimetic muscles under masticatory stimulus and finally without it. They learned to moderate their biting strength in order to achieve desired symmetry and movement. Voluntary smile were easily learned by the patients, while the possibility to smile under emotional stimulus has not been confirmed yet.

Evaluation of results requires the analysis of soft tissue corrections and their pre- and postoperative symmetry compared to the contralateral side. Some authors have concentrated their efforts on devising the most scientific way to quantitatively analyze cutaneous landmarks (Okada, 2001; Proff et al., 2006). Sforza et al. (2010) enhanced those analyses, introducing a very accurate scientific method to detect facial movements. Others authors consider an easy subjective clinical measurement more practical, giving anyone the ability to use it and to share data (Terzis and Noah, 1997). This is the classification method we chose.

No donor-site morbidity related to loss of masseter muscle function was observed in the study, except a transient limited mouth opening due to masseter muscle scar formation. This result is consistent with Brenner and Schoeller (1998) anatomical studies showing that both the presence of two or more nerve branches in 75% of cases and the closure of the temporalis muscle should avoid any postoperative dysfunction.

Masseter muscle atrophy has not been reported in the literature yet, though we observed it in one patient. Despite this the patient denied having any difficulty chewing. Aesthetic deficits could be addressed by a lipofilling procedure.

6. Conclusion

Masseteric–facial nerve anastomosis with an interpositional great auricular nerve graft is a valid alternative to hypoglossal–facial nerve anastomosis in early facial reanimation for complete facial paralysis, allowing the recovery of complete facial nerve function with low donor-site morbidity.

Conflict of interest

All authors disclose any financial and personal relationship with other people or organizations that could inappropriately influence their work.

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