Side-to-End Hypoglossal-Facial Neurorrhaphy for Treatment of Complete and Irreversible Facial Paralysis after Vestibular Schwannoma Removal by Means of a Retrosigmoid Approach: A Clinical and Anatomic Study

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■ BACKGROUND: **Facial paralysis secondary to a complete and irreversible anatomic or functional lesion of the facial nerve (FN) causes severe functional and psychological disorders for the patient. A large number of surgical techniques have therefore been developed for FN repair. Our objective was to propose a surgical FN reanimation protocol for patients with irreversible anatomic or functional postsurgical injury of the FN in the cerebellopontine angle after vestibular schwannoma resection.**

■ METHODS: **The clinical study included a total of 16 patients undergoing side-to-end hypoglossal-facial neurorrhaphy (SEHFN) since 2010, in which the FN injury was always secondary to vestibular schwannoma surgery in the cerebellopontine angle using a retrosigmoid approach. All patients had complete clinical facial paralysis at the time of the SEHFN. The anatomic study was conducted using 3 heads and necks (6 SEHFN).**

■ RESULTS: **Twelve months after surgery, FN function assessment with the House and Brackmann scale showed 2 patients with grade II, 13 patients with grade III, and only 1 patient with grade IV, and after 2 years, 4 patients had grade II, 11 patients had grade III, and 1 patient had grade IV. The average length of the anastomotic translocation portion of the FN in the anatomic study was 34.76 mm.**

■ CONCLUSIONS: **Side-to-end epineural suture of the FN, mobilizing its mastoid segment on the hypoglossal nerve with partial section of the dorsal aspect of the hypoglossal nerve, is a safe anatomic surgical technique for FN reanimation with outstanding clinical results.**

INTRODUCTION

Facial paralysis secondary to a complete and irreversible anatomic or functional lesion of the facial nerve (FN) causes severe functional and psychological disorders for the patient. A large number of surgical techniques have therefore been developed for FN repair, introduced and carried out by neurosurgeons; ear, nose, and throat surgeons; and plastic surgeons. Repair techniques depend to a large extent on the anatomic location of the lesion, etiology, and time intervals. From a neurosurgical point of view, irreversible FN injury is usually secondary to resection of brain stem tumors, cerebellopontine angle (CPA) tumors, particularly vestibular schwannomas (VS) and petrous bone, middle fossa or skull base tumors. Head trauma with skull base fracture is also a frequent cause of irreversible damage to the FN. In the neurosurgical setting, FN repair can be performed with direct neurotization techniques with FN neurorrhaphy, with or without interposed nerve grafts, or via FN

Key words
- Facial nerve
- Facial paralysis
- Hypoglossal nerve
- Mini mastoidectomy
- Neurorrhaphy
- Retrosigmoid approach

Abbreviations and Acronyms
CPA: Cerebellopontine angle
DM: Digastric muscle
FN: Facial nerve
H&B: House and Brackmann
HN: Hypoglossal nerve
ICA: Internal carotid artery
IJV: Internal jugular vein
P&T: Pitty and Tartor
PG: Parotid gland
SEHFN: Side-to-end hypoglossal-facial neurorrhaphy
VS: Vestibular schwannoma

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reanimation techniques by transferring another donor motor nerve, such as the hypoglossal nerve (HN), accessory nerve, motor branches of the third branch of the trigeminal nerve such as the masseter nerve, or using small distal branches of the contralateral FN, also with or without interposed nerve grafts.

HN transfer is the oldest technique used for FN reanimation by direct end-to-end suture. This classic end-to-end hypoglossal-facial neurorrhaphy technique involves completely severing the HN. In 1991, May et al.[1] proposed a side-to-end hypoglossal-facial neurorrhaphy (SEHFN) technique implanting the FN in the dorsal aspect of the HN. The HN was cut to approximately one third of its thickness, followed by microsurgical end-to-side epineural suture of the FN on the HN. To reach the HN easily and to perform a tensionless suture, an interposition nerve graft was needed. Later, Atlas and Lowinger[2] in 1997 and Asaoka et al.[3] in 1999 proposed a modified surgical technique that facilitated tension-free neurorrhaphy without interposition nerve grafts by mobilizing the mastoid segment of the FN.

In this article, we review SEHFN for FN reanimation using the homolateral HN and the mobilization of the mastoid segment of the FN in a series of patients with complete and irreversible FN paralysis secondary to VS resection in the CPA. An anatomic study and description of the surgical technique is also included in the article. Finally, a surgical management protocol for FN reanimation is proposed for patients with irreversible anatomic or functional postsurgical injury of the FN in the CPA after VS resection.

METHODS

Clinical Study

The series includes a total of 16 patients undergoing SEHFN since 2010, in which the FN injury was always secondary to VS surgery in the CPA using a retrosigmoid approach. When anatomic loss of the FN was verified during surgery (neurotmesis), the patient was proposed for a deferred early SEHFN. In case of postoperative complete facial paralysis with anatomic preservation of the FN (axonotmesis), an interval of at least 6 months was recommended waiting for electrophysiological or clinical recovery of the FN before SEHFN. In patients in which regeneration was absent, a deferred late SEHFN was proposed.

Demographic data collected for the study included age, sex, and size of the VS. Postoperatively, all patients received the same early rehabilitation program and free access to different surgical techniques for ocular protection, particularly temporary or definitive tarsorrhaphy and gold weight on the upper eyelid. Patients with anatomic FN preservation received postoperative treatment with corticosteroids. The time interval between FN injury and SEHFN was recorded. To assess patient clinical outcomes, 2 scales were used: House and Brackmann (H&B) grading of FN function,[4] and the Pitty and Tartor (P&T) scale of facial recovery after reanimation with HN transfer.[5]

Clinical evaluation was performed every 6 months until end of follow-up, with at least 2 years of follow-up after surgery. Regardless of motor recovery, facial synkinesis when speaking or eating and tongue atrophy were assessed separately.

Laboratory Dissection

This study was conducted using 3 heads and necks (6 SEHFN) at the Microneurosurgery Laboratory (Department of Anatomy and Human Embriology, University of Valencia, Spain). The heads were fixed using 10% formalin solution for a minimum of 3 months. The arteries (red silicone) and veins (blue silicone) were injected, and afterward dissection was performed under the surgical microscope with a x6 to x40 magnification (Zeiss OPMI Pico, Oberkochen, Germany). Cervical muscles, vessels, and cranial nerves of each specimen were studied. For the mini mastoidectomy, we used an electric drill (Medtronic Midas, Fort Worth, Texas, USA). Rhoton microdissectors surgical set and scalpel blades (#11 and #15) were used for the cervical dissection. In each step of the dissection process photographs were taken using the Canon EOS 1300D camera (Canon 100/2.8L Macro IS USM and Canon EF-S 18-55 mm IS, Tokyo, Japan), circular flash (Canon MR-14 EX II Macro Flash ring) and a Manfrotto MT055XPRO tripod (The Vitec Group, Cassola, Italy). The dissections were made after receiving authorization from the Research Ethics Committee for Health and Science Projects in the Clinical University Hospital (Valencia, Spain).

We performed an anatomic dissection approach based on 4 phases:

1. Cervical dissection (Figure 1A and B). A retroauricular incision over the mastoid followed by a curvilinear incision following the posterior aspect of the jaw angle was used for the anatomic approach. The digastric muscle (DM) was identified and exposed. The posterior retraction of the muscle exposes the cervical neurovascular bundle. Ordered from posterolateral to anteromedial, we find the internal jugular vein (IJV), spinal nerve, HN, internal carotid artery (ICA), vagus nerve (in a deeper layer), and external carotid artery.
2. Exposure of the mastoid process (Figure 1A and B). To fully expose the mastoid process, we proceed to uncover anteriorly the posterior edge of the external auditory canal; posteriorly we expose it until reaching a vertical line drawn caudally, approximately 1 cm anterior to the asterion; caudally we expose the entire lateral aspect of the mastoid process after the sternocleidomastoid muscle dissection and mobilization; and finally, we expose the mastoid superiorly 4–5 cm from the tip of the mastoid process, coinciding with the level of Henle's spine. Once the entire mastoid has been exposed, we identify anteriorly the extracranial segment of the FN that exits the skull through the stylomastoid foramen. The FN runs toward the parotid gland (PG) until its division in the pes anserinus.
3. Mini mastoidectomy (Figure 1C). The mastoid is drilled away to expose only the mastoid segment of the FN. Our anteroinferior limit is the stylomastoid foramen and cranially Henle's spine. Posteriorly an extension of 2–3 cm is needed for good exposure and to remove enough cortical bone covering the mastoid segment of the FN.
4. End-to-side hypoglossal-facial neurorrhaphy (Figure 1D). The FN is sectioned at the level of the mastoid segment's most proximal limit (at the level of Henle's spine) and dislocated caudally to perform the end-to-side HN-FN neurorrhaphy. A 1–2 mm section is made on the lateral side of the HN, and the FN is sutured with 9/0 monofilament using 6–8 stitches.

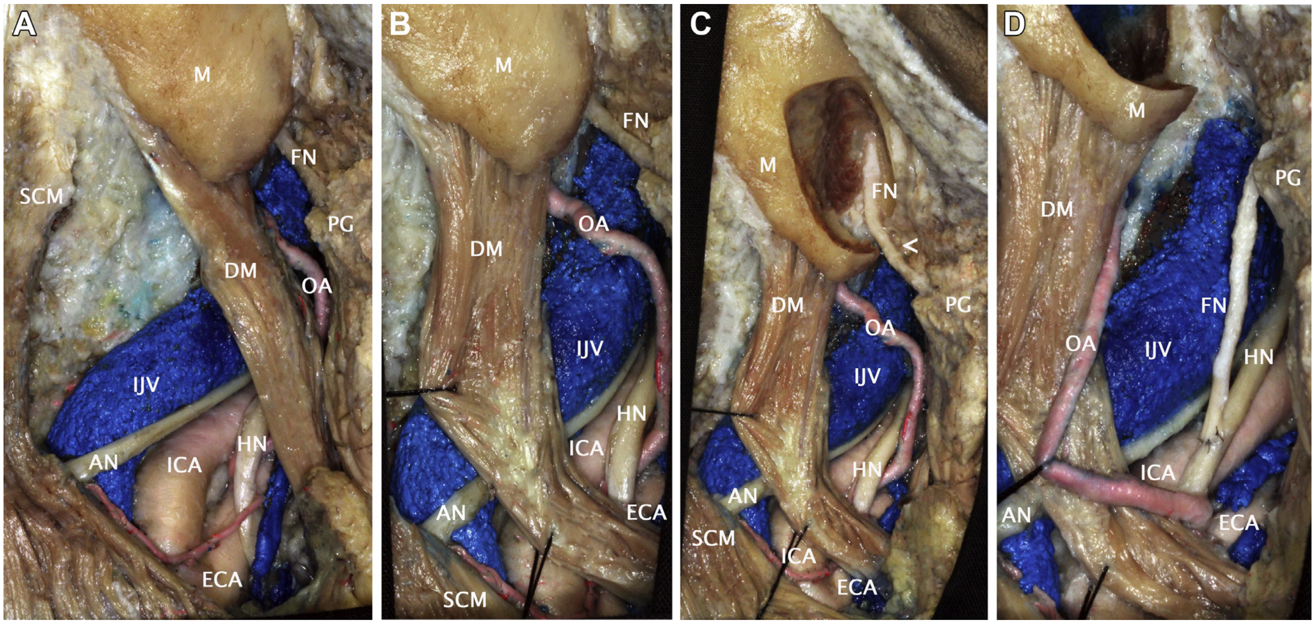

Figure 1. Anatomic study. (**A**) The skin and subcutaneous tissues of the lateral part of the cervical region have been removed on the right side. The extrapetrosal segment facial nerve (FN) has been exposed between the stylomastoid foramen in the mastoid (M) to the parotid gland (PG). The sternocleidomastoid muscle (SCM) has been detached from the M and reflected posteriorly, and the posterior belly digastric muscle (DM) is in place covering relevant neurovascular structures: accessory nerve (AN) going to the deep aspect of the SCM; the hypoglossal nerve (HN); the internal jugular vein (IJV); and the internal carotid artery (ICA), external carotid artery (ECA), and occipital artery (OA), running to the occipital region deeper to the DM. (**B**) The DM has been mobilized posteriorly, to show the exit of the HN between the IJV and the ICA. The anatomic relationships between the HN and the OA are very variable. (**C**) The mastoid segment of the FN has been exposed after a restricted mastoidectomy, limited by a horizontal line on the Henle's spine and a vertical line to the tip of the M. The stylomastoid foramen has been opened (<). (**D**) The M and extrapetrosal segments of the FN have been freed, mobilized, and luxated caudally. The proximal stump of the FN has been sutured on the HN. The OA is mobilized posteriorly.

Surgical Technique

The patient is placed in the supine position, with the head elevated and turned to the contralateral side. The previous standard retroauricular incision for the retrosigmoid approach is extended caudally below the angle of the jaw. The mastoid is localized, and the mastoid insertion of the sternocleidomastoid muscle is retracted backward and partially released. The posterior belly of the DM is identified, taking care to preserve the FN branch that innervates it, entering the muscle proximally and anteriorly. The muscle is released to the tendon and a rubber band is passed to mobilize it. The mastoid is now cleaned of soft tissue anteriorly as far down as the spine of Henle, taking care not to enter the external auditory canal, caudally exposing the entire tip of the mastoid and posteriorly usually to the edge of the previous retrosigmoid craniotomy. The FN is identified and isolated in its extrapetrosal portion from the stylomastoid foramen to the PG, where it is followed until its main division or pes anserinus (Figure 2A). The stylomastoid artery should be coagulated and sectioned. The mastoidectomy is carried out following the references described by Campero et al.[6] in 2012. A horizontal line is marked on the mastoid from Henle's spine, and another vertical line from the tip of the mastoid that runs almost 1 cm posterior the bony external auditory canal. The cortical bone of the mastoid is drilled caudally and anteriorly of these lines to the tip of the mastoid. The mastoid cells are exposed, respecting the posterior wall of the external auditory canal. The internal structure of the mastoid is very variable. In the ideal case of a large pneumatization, the surgeon must proceed to find the compact bone where the FN channel runs. If necessary, the extrapetrosal FN can be followed proximally to the stylomastoid foramen, and thus the mastoid FN channel can easily be found. With a high-speed drill, the FN is skeletonized in its entire mastoid segment and finally freed (Figure 2B).

We proceed now to identify the HN, located deeper in front of the DM. The HN is dissected proximally until its exit from the vascular aponeurotic sheath between the ICA medially and the IJV laterally (Figure 2C). We next pay attention to the proximal section of the FN, which is extracted from the bony canal and dislocated caudally to approximate it to the HN. The epineural tissue of the FN stump is removed with very thin scissors, and a section about one quarter the thickness of the HN is made at its concave dorsal aspect. Then we progress to end-to-lateral microsuture of the FN

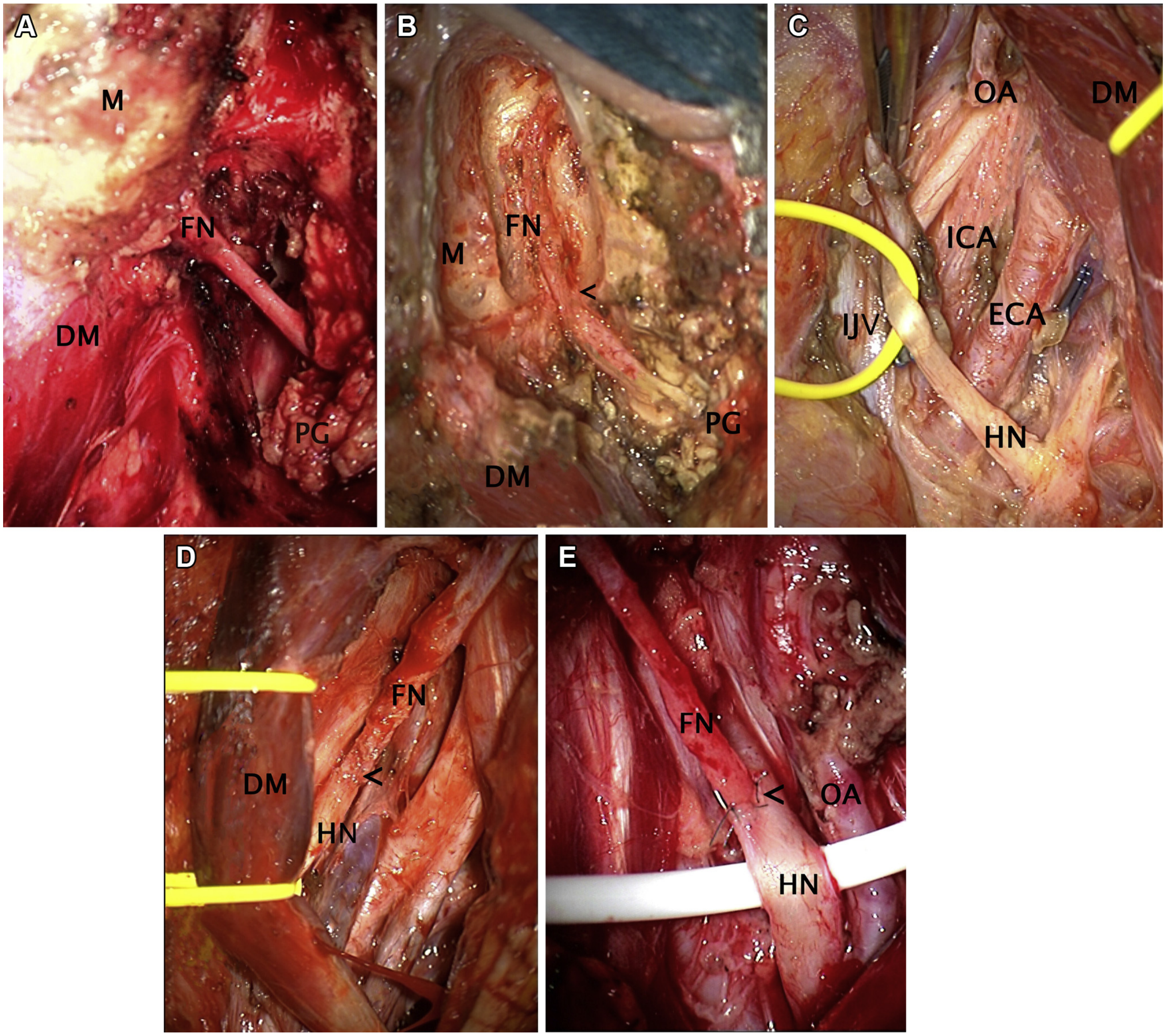

Figure 2. Surgical pictures. (**A**) Extrapetrosal exposure of the facial nerve (FN), between the mastoid (M) and the parotid gland (PG). (**B**) Exposure of the M and extrapetrosal segments of the FN after mastoidectomy and opening of the stylomastoid foramen (<). (**C**) The hypoglossal nerve (HN) has been isolated between the internal jugular vein (IJV) and the internal carotid artery (ICA). In this approach the occipital artery (OA) has been coagulated and divided to expose the most proximal segment of the HN, and the posterior belly digastric muscle (DM) has been mobilized anteriorly. (**D**) Picture showing the apposition of the FN on the HN ready for neurorrhaphy (<). The DM is displaced posteriorly in this particular case. (**E**) Close view of the completed suture line (<). Note the disproportion in size between the FN and the HN. ECA, external carotid artery.

to the HN with 6–8 epineural monofilament stitches of 9/0 (Figure 2D and E).

RESULTS

Surgical Anatomy

1. FN segments. The peripheral extrapetrosal portion of the FN located between the stylomastoid foramen and its division in the PG is referred to as the predivision extrapetrosal FN and has an average measurement of 14.12 mm (range, 12.8–15.3 mm) (Figure 1C; Table 1). In the mastoid process, mastoid cells vary considerably between specimens, but the location of the mastoid segment of the FN is quite constant. The distance in depth from the cortical bone at the level of Henle's spine to the FN in the mastoid canal is 13.45 mm (range, 12.3–13.7 mm). The mastoid segment of the exposed FN (from the spine of Henle to the stylomastoid foramen) measures on

Table 1. Anatomic Measurements with Relevance for the Side-to-End Hypoglossal-Facial Neurorrhaphy

	Minimum Distance (mm)	Maximum Distance (mm)	Average Distance (mm)
Prebifurcation extracranial FN	12.8	15.3	14.12
Mastoid canal related to cortical bone surface	12.3	13.7	13.45
Mastoid segment of the exposed FN	18.8	22.3	20.64
Anastomotic translocation portion of the FN	31.6	37.6	34.76
Distance from the stylomastoid foramen to the anastomotic point of the HN	28.6	32.4	30.03
Distance from the carotid bifurcation to the anastomotic point of the HN	13.1	16.3	14.23

FN, facial nerve; HN, hypoglossal nerve.

average 20.64 mm (range, 18.8–22.3 mm) (**Figure 1C**; **Table 1**). The FN portion that includes the mastoid segment and the predivision extrapetrosal FN is referred to as the anastomotic translocation portion of the FN. The average length of the anastomotic translocation portion of the FN is 34.76 mm (range, 31.6–37.6 mm) (**Figure 1D**; **Table 1**).

2. Position of the HN suture point relative to the stylomastoid foramen and primitive carotid bifurcation in the neck. The HN originates in the preolivary sulcus of the medulla. It passes through the hypoglossal canal at the level of the occipital condyle and exits to the extracranial space. It then extends down oblique in an inferior-anterior direction. It follows a parallel direction to the DM until it reaches the intermediate tendon of the digastric. In its extracranial way the nerve is located anteromedial to the IJV and posterolateral to the ICA. The average distance from the stylomastoid foramen to the easiest suture point of the HN is 30.03 mm (range, 28.6–32.4 mm). The average distance from the carotid bifurcation to the suture point of the HN is 14.23 mm (range, 13.1–16.3 mm) (**Figure 1D**; **Table 1**).

Clinical Results

The series includes 16 patients (12 women and 4 men) with an average age of 50.8 years (range, 31–67 years). The etiology of facial paralysis was in all cases postoperative after VS resection using a retrosigmoid approach. The mean size of the operated VS was 9.2 cc (range 3-25.1 cc), obtained by measuring the maximum dimensions of the extracanalicular tumor in the axial (a), coronal (c), and sagittal (s) planes and applying the formula $(a \times c \times s)/2$. Anatomic nerve injury (neurotmesis) was observed during surgery in 14 patients, whereas the rest had anatomic nerve preservation without recovery (axonotmesis) until the time of the SEHFN intervention, which was always >6 months after the nerve injury.

The SEHFN was carried out on average 7.8 months after surgery (range, 3–16 months), always by the same surgeon and using the same microsurgical technique. There were no intraoperative complications. Postoperatively, 1 patient had transient dysphagia for 2 weeks, and 1 patient had exudate from the ear owing to a skin injury in the external auditory canal during cleaning of the mastoid. There was no atrophy of the tongue or facial synkinesis in any of the patients operated.

All patients had complete clinical facial paralysis at the time of the SEHFN, regardless of type of FN lesion (H&B grade VI), and all improved after SEHFN. Almost all patients presented initial neurologic improvement 6 months after reanimation. Twelve months after surgery, FN function assessment with the H&B scale showed 15 patients with grade III, and only 1 patient with grade IV. On the P&T scale, all patients except 1 achieved good recovery at 12 months, and outcome in the remaining patient was fair after 2 years. Later, recovery was very slow and unremarkable, and patients did not improve their H&B or P&T scale grade. In clinical assessment it is necessary to consider that ocular closure function is improved by the ocular protection surgeries carried out in several patients. No patients made normal functional recovery in forehead mobility, so this item was not considered in H&B grading. When patient age or interval between injury and SEHFN are related to degree of recovery, there are no differences (**Figures 3** and **4**).

DISCUSSION

SEHFN

Facial paralysis secondary to VS resection continues to pose a problem for patients and surgeons. Other neurosurgical and craniofacial surgery procedures can also produce irreversible facial paralysis due to FN injury, as can trauma. In VS resection surgery, a direct relationship between postoperative facial paralysis and the size of the tumor and the surgeon's experience has been documented, although other secondary factors may be relevant in specific cases, such as degree of resection, surgical approach, cystic tumors, use of intraoperative electrophysiology, previous radiosurgery, and recurrent tumors.[7] When an anatomic loss of continuity of the FN is observed, the surgeon may attempt a primary repair if good quality proximal and distal trunk ends are available. In this event, the best option is primary end-to-end microsuture carried out after the tumor removal, with or without interposition of short nerve grafts.[7] If only 1 proximal FN end is in good condition, a long nerve graft can be connected, taken out of the craniotomy, and finally sutured on the extrapetrosal segment of the FN (Dott's anastomosis). The procedure can be performed in the same operation or in a delayed second operation.[7] However, if no proximal stump of the FN is available after VS removal, the FN cannot be directly repaired.

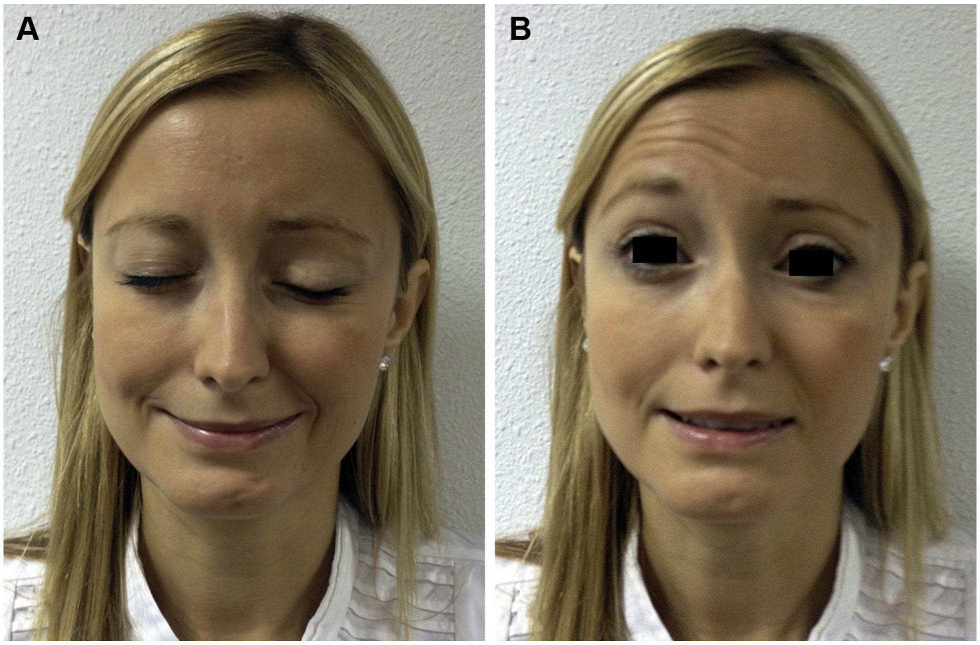

Figure 3. A 31-year-old woman with complete facial paralysis after removal of a 6.2 cc left accessory nerve. Three months afterward, side-to-end hypoglossal-facial neurorrhaphy was carried out. Pictures show the clinical result 3 years later with good buccal symmetry at rest (**A**) and with effort (**B**), good ocular symmetry and closure (gold weight in the upper eyelid), and no elevation of the eyebrow (reproduced with authorization of the patient).

Secondary repair of FN neurotmesis or axonotmesis with complete paralysis without recovery can be performed via FN reanimation with transfer of other motor nerves available in the area. Traditionally, HN has been used for reanimation of the distal FN stump in its extrapetrosal segment. In classic hypoglossal-facial neurorrhaphy, the whole HN is severed, and therefore sacrificed for end-to-end microsuture. Tongue atrophy occurs and facial recovery is accompanied by abundant synkinesis, given the disproportion between the number of fibers of both cranial nerves in favor of the HN.[3] Despite good FN reanimation, because of

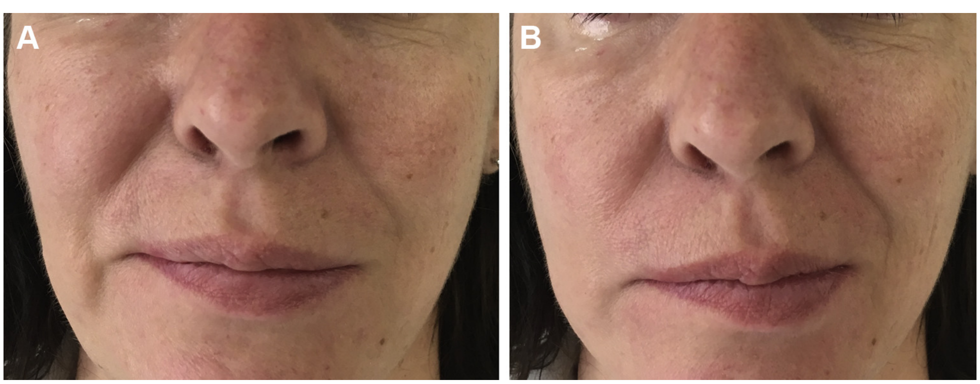

Figure 4. A 39-year-old woman with complete facial paralysis after removal of a 7.4 cc left accessory nerve. Six months afterward, side-to-end hypoglossal-facial neurorrhaphy was carried out. Pictures show the clinical result 6 months later (**A**), with a good buccal symmetry with effort (**B**) (reproduced with authorization of the patient).

these postoperative complications, other more conservative and efficient transfers are currently preferred over this technique to achieve FN reanimation.

Therefore to minimize these complications, end-to-side neurorrhaphy was proposed by May et al.[1] With this technique, between 30% and 50% of the HN is sacrificed for FN reanimation. The nerve is sectioned on the cranial and concave side, where nerve fibers do not contribute to lingual function of the HN, minimizing the sequelae of hemitongue atrophy and eventual secondary long-term deglution or phonation disorders.[8] A still more conservative technique proposed is simple epineural opening of the HN, without cutting any nerve fibers, to coaptate the FN on the HN with an epineural microsuture.[9,10] With this side-to-end hypoglossal-facial coaptation technique no neural fasciculus is sectioned. However, the recovery capability of this technique is far lower than in standard neurorrhaphy. With an epineural or fascicular microsuture the endoneural tubes of both nerve stumps are put into contact and the regenerated axonal sprouts growing from the proximal stump are allowed to enter the distal stump endoneural tubes to eventually reach the neuromuscular end plates.[11,12]

Any type of side-to-end microsuture between the HN and the FN faces the obstacle that the extrapetrosal segment of the FN is short and requires an interposition nerve graft, which hinders nerve regeneration and worsens clinical outcomes.[1,13,14] To solve this problem, Atlas and Lowinger[2] and Asaoka et al.[3] proposed obtaining a longer FN segment by releasing the mastoid portion of the FN, which is dislocated caudally, and enabling microsuture without tension. Asaoka et al.[3] measured an average distance of 17 mm between the division of the FN in the PG in the pes anserinus and the closest point of the HN and calculated that an FN segment of >30 mm is available after mobilizing the mastoid segment, leaving an excess of around 13 mm (range, 6–20mm) to make a tension-free suture. Campero and Socolovsky[15] made other measurements, and in an anatomic study measured >15 mm mastoid segment of the FN that could be mobilized, which added to the 19 mm that the FN measures from the stylomastoid foramen to its division in the parotid, provided enough for a tensionless neurorrhaphy with the HN, which is about 31 mm away from the stylomastoid foramen. Our results support these conclusions, showing that the mastoid segment of the FN added to the extrapetrosal segment gives an excess of 4 mm of FN to perform a tensionless suture on the most suitable point of the HN (**Table 1**). We selected this technique in all our patients.

There are few anatomic, surgical, and clinical studies addressing this SEHFN technique for FN reanimation in the literature,[8,14-20] yet these studies show good clinical outcomes in most patients, with absence of synkinesis and no significant atrophy of the tongue. In addition, when comparing SEHFN with end-to-end hypoglossal-facial techniques, the clinical results in terms of facial recovery are similar. This is attributed to the disproportion of the number of fibers between the FN and the HN in favor of the HN, with a sufficient amount of fibers provided by a part of HN for effective FN reanimation.[8,14-20]

One alternative to mobilizing the FN in its mastoid segment is longitudinal division of an HN segment into 2 halves to dislocate it cranially until it is approximated to the distal end of the FN sectioned in the stylomastoid foramen, thus obtaining a final end-to-end microsuture without tension.[21] This technique avoids mastoidectomy, but splitting the HN in 2 into a long segment entails a high risk of anatomic damage to a large number of nerve axons, which jeopardizes HN function and FN regeneration. This is because the HN is monofascicular and splitting a segment of the nerve lengthways into 2 halves can injure the axons, which randomly change their position along the length of the divided nerve. It is therefore not surprising that this technique is followed by tongue atrophy of varying severity. Moreover, neurorrhaphy of a split HN does not prevent synkinesis.[21-23]

The different clinical studies of FN reanimation techniques focus on favorable prognostic factors, in particular patient age and the time interval between nerve injury and repair. Martins et al.[16] state that best results are obtained in younger patients and when neurorrhaphy is done early. Guntinas-Lichius et al.,[24] studying 5 alternative FN reanimation techniques to SEHFN, conclude that prognosis is worse in patients over 60 years of age. Samii et al.[8] conclude that best outcomes are achieved if this procedure is performed within the first 2 years after FN injury, but patients with facial palsy for longer also have a chance of good functional recovery. Socolovsky et al.[14] observe a negative impact on delaying the reanimation surgery from the moment of the nerve injury. We propose that patient age and time interval from FN injury to reanimation might influence the quality of functional recovery through noncontrollable intermediate mechanisms, particularly muscular atrophy and fibrosis, soft tissue retraction, and elasticity loss. All these factors are more common in elderly patients and with a long interval from nerve lesion until reanimation. The influence of rehabilitation, patient socioeconomic and health status, and the center may therefore be very relevant to final clinical outcome.[13]

SEHFN has good results in buccal and facial asymmetry, as well as in ocular closure, but eyebrow elevation is almost never achieved. Until effective ocular closure exists, ocular protection must be ensured by tarsorrhaphy or gold eyelid weights. Although clinical results are satisfactory, a small number of patients do not improve.

Treatment of Post-VS Resection FN Damage

Intraoperative confirmation of neurotmesis of the FN allows surgeons to attempt primary repair of the nerve if possible, following the principles described earlier. As this direct primary repair is not usually possible, our treatment proposal is secondary reanimation by means of SEHFN, with FN repair carried out as early as possible. Although better functional outcomes have not been demonstrated, early repair reduces functional recovery times, which has a definitely favorable psychological impact on the patient and reduces the probability of ocular complications. From a strictly neuropathological point of view, all time that passes between FN neurotmesis and SEHFN is lost time. Wallerian nerve regeneration begins inexorably a few weeks after the early phase of Wallerian degeneration.[5] All FN reanimation techniques are followed by months of waiting for functional recovery until regenerated axonal sprouts reach enough number of end plate neuromuscular targets. Electrophysiology studies indicate that revitalization begins a mean of 4–5 months after neurorrhaphy, and clinical recovery begins a few weeks later.[24] Therefore FN rehabilitation should be intensive and continuous from the first moment to preserve muscle and soft tissue elasticity and tone, avoid facial asymmetry, and prevent synkinesis. In addition, the eye must be actively protected by tarsorrhaphy or placement of a weight on the upper eyelid.

CONCLUSIONS

Irreversible facial paralysis due to FN injury after VS surgery in the CPA produces significant problems for patients. HN transfer is a very effective donor for surgical FN reanimation, regardless of surgical technique. However, the technique selected should not involve completely severing the HN or use of grafts, whereas end-to-side coaptation does not seem to offer enough regenerative contribution. FN reanimation should be offered to patients according to a well-established protocol, including continuous and intensive rehabilitation treatment and prevention of ocular complications. End-to-side epineural suture of the FN, mobilizing its mastoid segment on the HN with partial section of the dorsal aspect of the HN, is a safe anatomic surgical technique for FN reanimation with outstanding clinical results, which avoids the sequelae derived from the severing of the HN.

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