Masseter-to-Facial Cranial Nerve Anastomosis: A Report of 30 Cases

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BACKGROUND: Facial nerve paralysis (FP) is a possible complication of cerebellopontine angle tumor surgery. Several donor nerves have been used in the past for facial reanimation. We report the results of 30 cases of masseter-to-facial anastomosis.

OBJECTIVE: To prospectively evaluate the efficacy of V to VII anastomosis after FP.

METHODS: In a prospective study, we included 30 consecutive patients with FP (20 women and 10 men) whose mean age was 48.8 yr (32-76 yr). In almost all cases, FP developed after cerebellopontine angle tumor surgery (29 patients), whereas in one case, FP occurred after skull base trauma. Pre- and postoperative evaluation of facial nerve function was performed using the House-Brackmann (HB) scale and the Sokolovsky scale, as well as by electromyography. Follow-up ranged from 11 to 51 mo and averaged 22 mo.

RESULTS: All patients achieved functional recovery of the facial nerve from VI to either III or IV HB degree. Patients with short time FP showed significantly better postoperative recovery.

CONCLUSION: The results of the V to VII anastomosis demonstrate a significant improvement of facial nerve function and virtually no complications.

KEY WORDS: House-Brackmann scale, Facial nerve palsy, Anastomosis, Facial nerve, Masseter nerve, Masseter-to-facial anastomosis

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Facial nerve paralysis (FP) is a well-known complication of the removal of cerebellopontine angle (CPA) tumors, mostly—but not exclusively—acoustic neuromas. This evidence represents a very difficult-to-accept disability for its obviously significant negative impact in the social life of the affected individual.

The refinement of microsurgical technique and the availability of efficacious parasurgical treatment modalities such as modern radiosurgery have dramatically decreased the incidence of such a complication following intracranial procedures involving the facial nerve, but postoperative FP still represents a serious risk particularly in operating acoustic neuromas of large to giant size,[1] in which the nerve fibers are often spread apart and embedded in the tumor capsule strongly adhering to the compressed brainstem.

ABBREVIATIONS: CN, cranial nerve; **CPA,** Cerebellopontine angle; **EMG,** electromyography; **FP,** Facial paralysis; **HB,** House-Brackmann; **POFRA,** postoperative facial reanimation

For this reason, surgical reinnervation should represent an obligatory step after intraoperative facial nerve lesion, and surgical techniques for performing this should be available in any neurosurgical team that deals routinely with CPA tumors.

Several nerves have been used in the past as a donor nerve for lesioned facial nerve reinnervation, including the spinal accessory nerve,[2,3] the upper cervical peripheral roots[1,2] and, mostly, the hypoglossal nerve.[2,4] All these techniques have drawbacks mostly related to their relative distance from the anatomic site, where anastomosis must be performed as well as to the clinical consequences following their harvesting, ie, the loss of function of the muscles innervated by them and involuntary facial-buccal movements.

In relatively recent years, the use of the masseter nerve as a donor nerve for facial reanimation has been introduced,[2,5] quickly gaining popularity.[2,6-9] In fact, although its surgical exposure requires a learning curve as any delicate surgical procedure, masseter nerve harvesting has several advantages, including very limited—if

TABLE 1. General Characteristic of Present Patients

Patient	Sex	Age	Aetiology of CN VII palsy	Condition of CN VII	Palsy duration	Beginning of recovery FM after CN V-VII anastomosis (mo)	Ending of recovery FM after CN V-VII anastomosis (mo)	Follow-up, mo	HB at last follow-up	POFRA scale at last follow-up
1	M	54	TS	Resected	1	5	10	19	3	10
2*	F	43	TS	Exact unknown	8	8	18	24	4	6
3*	F	53	TS	Exact unknown	9	8	16	52	4	7
4	M	45	Trauma	Exact unknown	9	9	17	46	4	6
5	F	76	TS	Resected	2	6	14	16	4	8
6	F	32	TS	Resected	2	5	12	15	3	9
7	M	46	TS	Preserved	6	7	14	19	4	7
8	F	44	TS	Resected	2	5	11	12	4	8
9	M	38	TS	Resected	1	4	8	11	3	9
10	F	52	TS	Preserved	8	8	16	17	4	6
11	F	47	TS	Preserved	8	9	15	15	4	6
12	F	34	TS	Resected	1	4	10	16	4	7
13	M	43	TS	Resected	1	6	13	25	3	8
14	F	56	TS	Resected	1	6	10	28	3	10
15	M	33	TS	Resected	2	7	12	34	4	7
16	F	44	TS	Resected	2	6	14	36	3	8
17	F	62	TS	Resected	2	6	12	17	3	8
18	F	44	TS	Preserved	10	8	17	19	4	7
19	F	65	TS	Resected	1	4	10	24	3	9
20	F	34	TS	Resected	1	5	12	19	3	9
21	M	37	TS	Resected	1	5	10	26	3	8
22	F	42	TS	Resected	1	6	13	14	3	8
23	F	53	TS	Resected	1	4	12	28	3	8
24	M	58	TS	Preserved	7	7	14	18	4	7
25	F	44	TS	Resected	2	5	10	20	4	7
26	M	56	TS	Resected	1	4	8	16	3	9
27	F	61	TS	Resected	2	7	15	24	4	6
28	F	47	TS	Resected	2	5	9	15	3	8
29	F	52	TS	Preserved	9	8	12	12	4	7
30	M	68	TS	Resected	1	4	9	16	4	7

any—clinical consequences of its transection, close anatomic proximity to the peripheral facial nerve, and, as a rule, adequate diameter to be anastomosed to it, with real possibility to perform an end-to-end anastomosis without having to use interposed nerve graft.[2]

We present here our experience with 30 cases of masseter to facial, otherwise denominated V to VII anastomosis, operated on in our center in the last 4 yr.

METHODS

Patients Characteristics

A total of 30 patients harboring peripheral FP have been operated in a 4-yr time span (2013-2016). The causes of FP are summarized in Table 1.

Patients were enrolled prospectively with the aim of evaluating the surgical technique of masseter-to-facial (V-VII) anastomosis. Informed consent was obtained by patients and/or relatives. The study was approved by the Institutional Ethical Committee.

A total of 20 women and 10 men whose age ranged from 22 to 76 yr and averaged 48.8 yr participated in the study. In 21 out of the 30 cases, there was a verified surgical injury of the facial nerve during CPA surgical procedure performed in our center, during the removal of large to giant lesions (≥4.0 cm). In 6 cases, the anatomic integrity was respected, but the function was lost, as demonstrated by the intraoperative neurophysiological monitoring. Three patients were transferred from other institutions following either CPA surgery (2 cases) or head injury with fracture of the skull base (1 case) for the specific purpose of facial reanimation. Facial electromyography (EMG) control was mandatory.

In the 21 cases of intraoperatively verified facial nerve injury, the anastomosis was performed relatively early after nerve injury (1-2 mo), whereas in the remaining 9 cases, follow-up clinical and EMG evaluations have been performed before submitting the patients to restorative surgery (6-10 mo). No sign of spontaneous reinnervation had been noted in those 9 patients before performing surgical neurorrhaphy.

Patients were evaluated in our outpatient clinic by examination and EMG before operation, as well as at 6, 12, and 18 mo following surgery. Longer follow-up information was achieved by telephone interview and sometimes also by obtaining pictures from the patients themselves. As far as the masticatory function, an objective evaluation of mandibular symmetry was performed whilst the subjective evaluation of masticatory function by the patient himself was also considered. We considered the level and the timing of subsequent recovery for statistical analysis.

Management Protocol and Method

The function of the facial nerve was assessed by using House-Brackmann (HB) scale and using the scale proposed by Socolovsky et al[10] and confirmed by EMG control. All patients obviously showed preoperatively paralysis of VI degree according to the HB scale. EMG study was routine and, as a rule, showed preoperatively a complete absence of M-response as a sign of total loss of function. Also, spontaneous activity in the form of fibrillation potentials of varying degrees was identified as a manifestation of acute denervation of the mimic muscles.

In 21 patients, in whom verified anatomic damage of the facial nerve had occurred (group 1), the restorative intervention was performed relatively early after the original surgery (1-2 mo), whereas in the remaining 9 patients, in whom no spontaneous recovery of cranial nerve (CN) VII function had been observed following original surgery (group 2) at which no anatomic nerve lesion had been verified, masseter-to-facial nerve anastomosis was performed on average 10 mo after previous surgery.

All patients were photographed and filmed pre- and postoperatively. Follow-up ranged from 11 to 51 mo and averaged 22 mo. Assessments at 6, 12, and 18 mo after surgery were performed by the same medical personnel. Patients from other regions, who could not come to our institution for longer follow-up, sent photos and videos of themselves.

For the purpose of evaluation of the results, the degree of functional recovery and the timing between surgical reinnervation and appearance of the first sign of functional recovery were considered. Statistical analysis was performed using the analysis of variance test, and value of $P > .05$ was considered significant.

Surgical Technique

A vertical curved incision passing 0.5 cm in front of the tragal cartilage was performed. The masseter branch of the trigeminal nerve is usually found 3 cm in front of the tragus, 1 to 1.5 cm below the zygomatic arch and 1.5 cm deep to the surface of the masseter. First, the distal rami of facial nerve are detected in the subcutaneous fat. In patients who had no intraoperative facial nerve lesioning, we performed direct stimulation of the peripheral stump of the nerve for confirming lack of spontaneous occult recovery. Then, proximal dissection is performed from the distal rami to the main trunk of the nerve. In this respect, Zuker's point[11] can be a very useful anatomic reference for identifying peripheral facial nerve branches. After that, the masseter nerve is detected within the masseter muscle, as a rule on the superficial surface of the deepest of the 3 lobes of the muscle itself. Function of the nerve is confirmed by intraoperative electrostimulation. Facial nerve is then cut proximally, and the masseteric ramus of the trigeminal nerve is cut distally. Then, an end-to-end neurorrhaphy is performed by epi-perineural suture using a 9/0 atraumatic needle. Standard closure of wound is performed (Figure 1).

RESULTS

At the time of last follow-up, all patients achieved functional recovery of the facial nerve from VI to the III or IV HB degree (Table 1). We divided patients in 2 groups: group 1 with short-time FP (1-2 mo) and group 2 (with longer duration of symptoms) and analyzed the level and the dynamics of functional recovery. Definitely better results were obtained in the first group, in which there was functional improvement in all cases; in 14 patients, facial nerve function recovered to III HB degree, and in 7 patients, it improved up to IV degree. In the second group of patients, all the 9 cases showed improved up to HB IV. We also evaluated the degree of recovery of the function of facial muscles using the POFRA scale (postoperative facial reanimation scale) proposed by Socolovsky et al[10] and observed the dynamics of restoration of facial nerve function. The time of function recovery was shorter in the first group (6 vs 8 mo, $P = .003$) (Table 2).

We did not observe early or late surgical postoperative complications. In particular, cases of masseter atrophy and/or patient complains of weak chewing were not detected. A fact worth of note is that we noted further improvement of facial nerve function up to 18 mo following anastomosis (one patient); however, no improvement was observed in longer follow-up.

Clinical Case

A 54-yr-old patient (Figure 2) was operated on for a giant vestibular schwannoma (53 × 42 mm). Anatomic damage of the facial nerve occurred during the removal of neoplasm, and complete interruption of nerve conduction was detected by intraoperative EMG monitoring. After 1 mo of electrical stimulation, EMG of the facial musculature was performed, which revealed total FP with complete loss of conduction and extensive denervation of mimic muscles.

Masseteric-facial nerve anastomosis was performed 35 d after tumor surgery, and significant subsequent improvement was observed. According to the EMG data at the 6-mo follow-up, there were signs of reinnervation of the facial muscles more pronounced in the orbicular muscle of the mouth.

Follow-up

Clinical follow-up is still ongoing because longer-term improvement cannot be ruled out, although as stated above, we did not observe functional improvements after 18 mo of postoperative observation (Table 3).

Accordingly, we recommend our patients to undergo routinely physical therapy and electrical stimulation of the affected muscles. Also, other reconstructive surgical options are being considered; however, no patient by now expressed a wish to undergo further procedures because all had preferred a "wait and see" strategy at least for the moment.

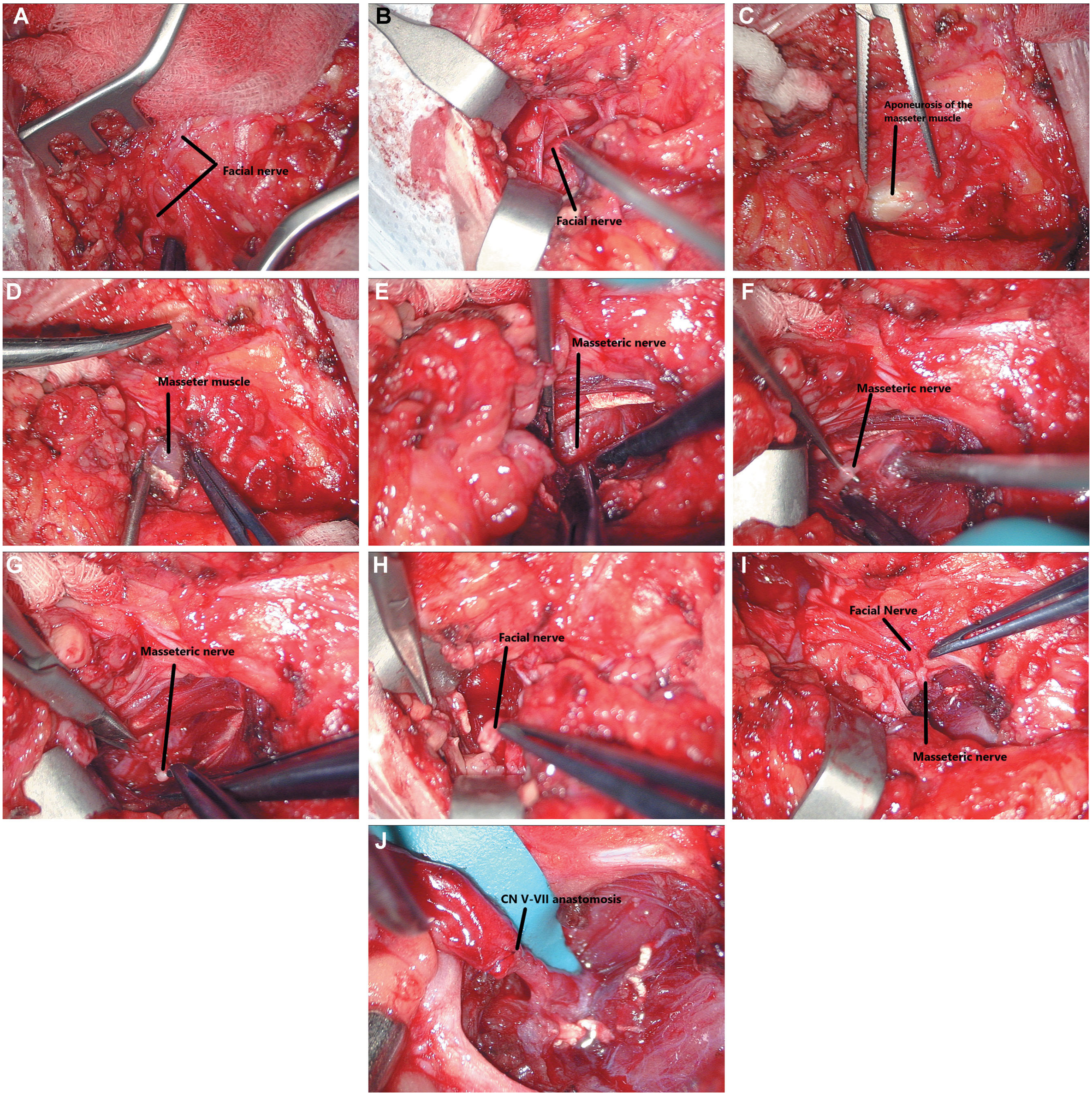

FIGURE 1. *The steps of operation. Facial nerve exposure* **A** *and* **B**, *exposure of masseter muscle* **C**, *section of masseter muscle* **D**, *exposure of masseteric nerve* **E** *and* **F**, *section of masseteric nerve* **G**, *preparation of facial and masseteric nerves for anastomosis* **H** *and* **I**, *and anastomosis completed* **J**.

DISCUSSION

Surgical injury of the facial nerve during complex CPA tumor surgery is infrequent and even not at all nowadays. Surgical reconstruction of injured facial nerve is a priority for many surgeons, who have been dealing with CPA tumors for many years for more than a century. FP causes obvious psychological consequences to the affected patient, who is, in most cases, in her/his most socially active period of life. In such a situation, it is obligatory to find a solution.

Donor Nerves

Several possible donor nerves to be anastomosed have been tried during the years, including the injured facial itself, whether

TABLE 2. The Effectiveness of Facial Nerve Recovery After Early and Late V-VII Anastomosis

Patients	Number of patients	Mean follow-up, mo	Mean follow-up, mo ± SD	Mean duration palsy, mo	Functional recovery at the last follow-up	POFRA scale	Statistical correlation
Group 1	21	20.9 (from 11 to 36)	20.9 ± 6.2	1.3	Improvement to HB III in 14 patients	8.6	$P = .001$
		19.7 (from 12 to 34)	19.7 ± 7.3	1.7	Improvement to HB IV in 7 patients	7.1	$P = .001$
Group 2	9	24.6 (from 12 to 52)	24.6 ± 7.1	8.3	Improvement to HB IV in 9 patients	6,5	$P = .001$

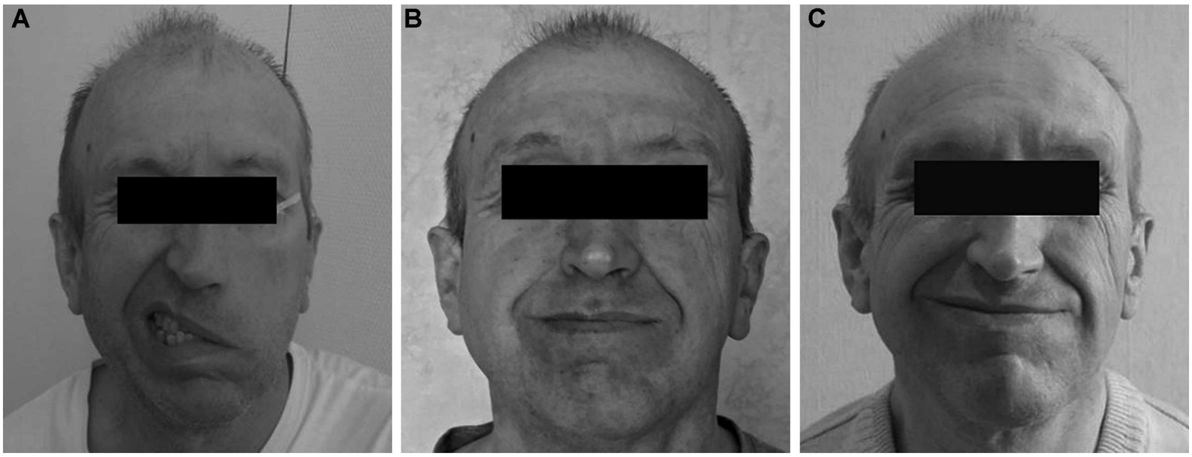

FIGURE 2. *Dynamic of facial nerve function recovery (**A**, before the operation, **B**, 4 mo after operation, and **C**, 6 mo after operation). Improvement from VI to II HB scale degrees is evident.*

TABLE 3. The Duration of Facial Recovery

Group divided according to duration of facial palsy before surgical reinnervation	Number of patients	Beginning of recovery after CN V-VII anastomosis (mo)	Ending of recovery after CN V-VII anastomosis (mo)	Functional recovery at the last follow-up	Statistical correlation
Group 1	21	5.2 (4-7)	11.3 (8-15)	Improvement to HB III-IV in 21 patients	$P = .003$
Group 2	9	8 (7-9)	15.4 (12-18)	Improvement to HB IV in 9 patients	

anastomosed end to end (with or without being transposed) or via a donor nerve (the sural nerve as a rule) transplant,[1,9,11,12] the contralateral facial nerve with a cross-face anastomosis using the sural nerve,[8,13] the spinal accessory nerve,[9,11] the upper cervical roots,[11,12] and the hypoglossal nerve.[1,11] The latter one has been the most frequently used donor nerve for facial reanimation by the neurosurgical community, whilst spinal-facial anastomosis carries on the unavoidable risk of postoperative trapezius atrophy, a fact that explains why this procedure, although being in use decades ago, later lost its initial popularity.

Masseter-to-Facial Anastomosis

Approximately 35 yr ago, Spira[3] published an elegant anatomic study that proposed the reappraisal of a technique already described in 1925 by Escat and Viela,[5] who used the masseter as a donor nerve. The masseter nerve originates from the third branch of trigeminal nerve right after its exit though the foramen ovale and courses in the infratemporal fossa inferior to the zygomatic arch, giving off small branches but keeping its original size up to the mandibular angle. In spite of other studies described in subsequent years, its surgical anatomy, and its suitability as a donor nerve for restoring severed facial nerve function,[11] it was only in the early 2000s that its clinical use was reported.[11,14] Afterwards, this method for facial reanimation has gained definite popularity, either in conjunction with cross-face, facial-to-facial anastomosis (the so-called babysitting technique) or alone.[15] There is a consistent number of publications by plastic reconstructive surgeons who described the surgical indications and goals of the V to VII anastomosis, in most cases in conjunction with either a cross-face nerve anastomosis to be performed at a second stage or with muscular transfers in order to achieve the best functional results in terms of restoring face functions.[7] Nevertheless, its use of a donor nerve for facial reanimation has been mentioned very seldom in neurosurgical literature,[10] sometimes also as a single case report.[16]

Present Experiences

It is our opinion, however, in the surgical armamentarium of a well-organized neurosurgical team that the technique of V to VII anastomosis should be available. Nerve anastomosis can be made relatively early after a known intraoperative injury of the facial nerve and prevents the risk of facial muscles atrophy that would make further reconstructive surgery useless. The facial nerve function following this type of anastomosis can be restored to a point that successive additional surgery may even be unnecessary.

The advantages of the V to VII anastomosis over other nerve donor techniques, and in particular over the hypoglossal-facial anastomosis, have been convincingly demonstrated by Hontanilla et al[2] whereas several papers have described how to expose the masseter nerve and the level of zygomatic arch—and inferiorly to it—in order to mobilize it conveniently enough to anastomose it end to end to the facial nerve.[2,7] We followed the same principles. The masseter nerve has been encountered within the muscular fibers, and its adequate mobilization has required severing no more than 2 branches, with no apparent clinical consequences. Using the masseter nerve as a donor nerve usually does not cause significant muscle atrophy, particularly if the descendent branch is used.[11,17]

We never used grafts because the length of facial and masseter nerve were enough for all cases. End-to-end anastomosis has been performed in all cases, although very often the size of the masseter did not match the one of the facial nerve stump. However, this fact did not prevent achieving postoperative good functional results. Sometimes, when the size difference between the 2 stumps appears to be too big for performing an adequate neurorrhaphy, the zygomatic-buccal branches of the facial nerve can be used. In this case, the "Zuker's point"[11]—a point midway from the root of the helix of the ear to the commissure of the mouth—can be conveniently used as a reference; however, we never recurred to this solution in the present cases.

This surgical technique is, in our opinion, quite straightforward because of its favorable surgical anatomy and the lack of clinical consequences for masseter harvesting, although its learning curve is not particularly long, and its results are quite satisfactory.[18] We are aware that a cross facial-to-facial nerve grafting could be considered as a first step in our patients; however, we elected to use the present technique also considering that no grafting would have been required. The possibility of directly anastomosing end-to-end nerve stumps in our opinion could have given better chances of nerve fibers regrowth following surgical reinnervation.

V to VII CN vs Hypoglossal-Facial Anastomosis

Harvesting hypoglossal nerve is technically relatively straightforward and provides a stump of adequate diameter for being anastomosed to the trunk of the injured facial nerve. However, most patients complain of postoperative tongue atrophy, which may somehow also affect speaking and eating, and the more recently proposed partial section of the nerve with interposed autologous nerve graft does not eliminate such a risk. Halil et al[4] demonstrated that 60% patients had severe hemitongue atrophy and hemiglossal functional loss in the postoperative follow-up period. In the remaining patients, the hemitongue atrophy was found to be moderate. Moreover, facial synkinesias are quite frequent following hypoglossal-facial anastomosis and may affect negatively postoperative functional results. Albathi et al[19] showed that masseter nerve grafting resulted in earlier recovery compared with hypoglossal nerve grafting. Socolovsky et al[10] compared the results of hypoglossal-facial with masseter-to-facial anastomosis following facial nerve injury and found that, contrary to what was reported in the plastic surgery literature,[2] the results of direct hypoglossal-facial anastomosis were slightly superior. However, they stressed that direct anastomosis would require additional mastoidectomy, thus making this procedure definitely more complicated, and we conclude that the slight difference in the results of both techniques would not be sufficient to recommend one against to another. The comparison between the V to VII and the hypoglossal-facial anastomosis grafting was beyond the scope of the present study, which simply intended to evaluate prospectively a novel surgical technique. The analysis of the relevant literature let us go on with evaluating the technique we have being using without making a direct comparison with other reconstructive techniques.

Timing of Reconstructive Procedure

The timing of surgical reanimation of facial nerve is a matter of significant controversy. The most popular concept advocates early surgical intervention and suggests that the delay in performing the anastomosis should be as short as possible, and any case should be less than 1 yr.[4,20,21] In 2011, Rivas et al[22] retrospectively reviewed the facial functional outcomes of 243 patients who developed FP after vestibular schwannoma resection, despite an anatomic preservation of the facial nerve. They conclude that the rate of facial nerve recovery during the first 6 mo after total loss of function is an early independent predictor of ultimate facial nerve recovery. In the study of Albathi et al,[19] the patients who showed no signs of recovery by 6 mo after CPA surgery but declined facial reanimation surgery demonstrated at best a HB grade V recovery after 18 mo of observation.

Results of the Postoperative Studies

Our experience strongly suggests that the earlier reinnervation procedure performed after the facial nerve injury can receive the better functional outcome will be obtained, although reasonably good results can be expected also in those patients operated on after a longer period. Functional recovery becomes apparent approximately 4 mo following reconstructive surgery, and improvement is still ongoing in same patient. No patient has undergone further reconstructive procedures until now. We cannot exclude that functional results can be further improved by some specific additional plastic reconstructive procedure. As stated above, we strongly encourage our patients to undergo intense physical therapy. As further improvement cannot be excluded, it may be due to the well-known brain capacity for functional readaptation.[2,7] We want to stress that because the muscular tone of the face is maintained following the anastomosis, future additional reconstructive procedures can be seriously considered. This is something that we will leave to the judgment of the patient him/herself. In addition, we stress that neither masticatory dysfunction nor facial sinkynesias—which frequently occur with facial-hypoglossal anastomosis[1,4,17]—were reported by the present patients, a fact that represents another reason for recommending the technique described in the present study.

CONCLUSION

CN V-VII anastomosis demonstrates significant improvement of facial function with virtually no complications. Earlier nerve transfer is crucial factor for better functional recovery, especially in patients with intraoperatively verified injury of the facial nerve.

Disclosures

The authors have no personal, financial, or institutional interest in any of the drugs, materials, or devices described in this article.

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COMMENT

This is a well-produced descriptive video of the resection of the 7th cervical rib for thoracic outlet decompression. The video details the dissection and care required for removal of the 7th cervical rib. Although not a novel procedure or video, it provides great visualization of the anatomy and how the important structures are manipulated during dissection. Meticulous dissection and protection of the brachial plexus are required for a successful outcome. The relationship of the cervical rib to the subclavian artery and surrounding brachial plexus trunks is depicted well here. It is important to emphasize that the brachial plexus components and the subclavian artery should be exposed and secured before any bony work is started. Anterior scalenectomy is not shown in the video but is an integral part of thoracic outlet decompression regardless of the presence or not of a cervical rib. Care should be taken to protect the phrenic nerve which lies directly anterior to the anterior scalene muscle. The patient's clinical follow up period is too short to make a conclusion that there was lasting clinical benefit from the procedure.

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