Hypoglossal-Facial Nerve Interpositional-Jump Graft for Facial Reanimation without Tongue Atrophy

Mark May, Steven M. Sobol and Sara J. Mester

Otolaryngology -- Head and Neck Surgery 1991 104: 818

DOI: 10.1177/019459989110400609

Hypoglossal-facial nerve interpositional-jump graft for facial reanimation without tongue atrophy

MARK MAY, MD, FACS, **STEVEN M. SOBOL**, MD, FACS, and **SARA J. MESTER**, RT(R), Pittsburgh, Pennsylvania, and Decatur, Illinois

The hemitongue paralysis that occurs as a result of a classic hypoglossal-facial nerve crossover procedure can result in profound functional deficits in speech, mastication, and swallowing. The procedure is not an option in patients with bilateral facial paralysis or those at risk for combined cranial nerve deficits. To address some of the drawbacks and limitations of this classic procedure, we developed the hypoglossal-facial nerve interpositional jump graft (12-7 jump graft) procedure. This procedure involves interposing a nerve graft between a partially severed but functionally intact twelfth cranial nerve and the degenerated seventh cranial nerve, and is often combined with other reanimation procedures. To date, we have performed 33 12-7 jump graft procedures in 30 patients (three were treated for bilateral facial paralysis); this report describes the procedure and its indications, and details the results of 23 procedures performed in 20 patients for whom 24-month follow-up data are available. Twelfth nerve deficits occurred in only three patients in this report. Recovery of facial function began between 3 and 24 months postoperatively. Facial tone and symmetry were achieved in every patient, no patient had significant mass movement, and 13 patients (two of whom were treated for bilateral facial paralysis) had excellent and three had superb restoration of facial movement. These results show the 12-7 jump graft to be a valuable adjunct for facial reanimation in selected patients. (OTOLARYNGOL HEAD NECK SURG 1991;104:818.)

Hypoglossal facial nerve anastomosis remains the most popular technique for reanimating a paralyzed face when facial nerve grafting or repair is not possible. Recovery of facial function is often noted as early as 4 to 6 months after this classic procedure, and although mass movement occurs often after hypoglossal-facial nerve anastomosis, most patients have good facial symmetry at rest, voluntary movement with tongue thrusting, and, occasionally, control of individual muscle groups.[1]

Nevertheless, this procedure leads to paralysis of the ipsilateral tongue muscles, which can result in significant speech, mastication, and swallowing difficulties. These difficulties can be incapacitating in patients who have, or have the potential for, bilateral and/or other cranial nerve deficits—particularly those who have experienced injury to the tenth cranial nerve, who have an existing twelfth cranial nerve loss, or who have neurofibromatosis, type II. Naturally, hypoglossal-facial nerve anastomosis is not appropriate for reanimating both sides of the face in patients with bilateral facial paralysis. In addition, some patients refuse to accept the sequelae of sacrificing twelfth cranial nerve function.

Other methods of facial reanimation that are appropriate for these patients include spinal accessory–facial nerve crossover,[2] cross-facial nerve grafting,[3] and/or temporalis muscle transposition[4] combined with various eyelid-reanimating procedures.[5,6] In addition, we developed a hypoglossal facial nerve interpositional jump graft (12-7 jump graft) procedure that provides innervation of mimetic facial muscles without some of the drawbacks and limitations of the classic procedure. The 12-7 jump graft procedure involves interposing a nerve graft between a partially severed twelfth cranial nerve and either the main trunk or selected distal branches of the degenerated facial nerve. The procedure is rarely

From the Department of Otolaryngology–Head and Neck Surgery, University of Pittsburgh School of Medicine (Dr. May), and the Facial Paralysis Center, Shadyside Hospital, Pittsburgh (Ms. Mester). Dr. Sobol is in private practice in Decatur, Illinois.

Presented at the Annual Meeting of the American Neurotology Society, Palm Beach, Fla., April 29, 1990.

Received for publication June 14, 1990; revision received Nov. 5, 1990; accepted Jan. 3, 1991.

Reprint requests: Mark May, MD, 510 South Aiken Ave., Pittsburgh, PA 15232.

23/1/27699

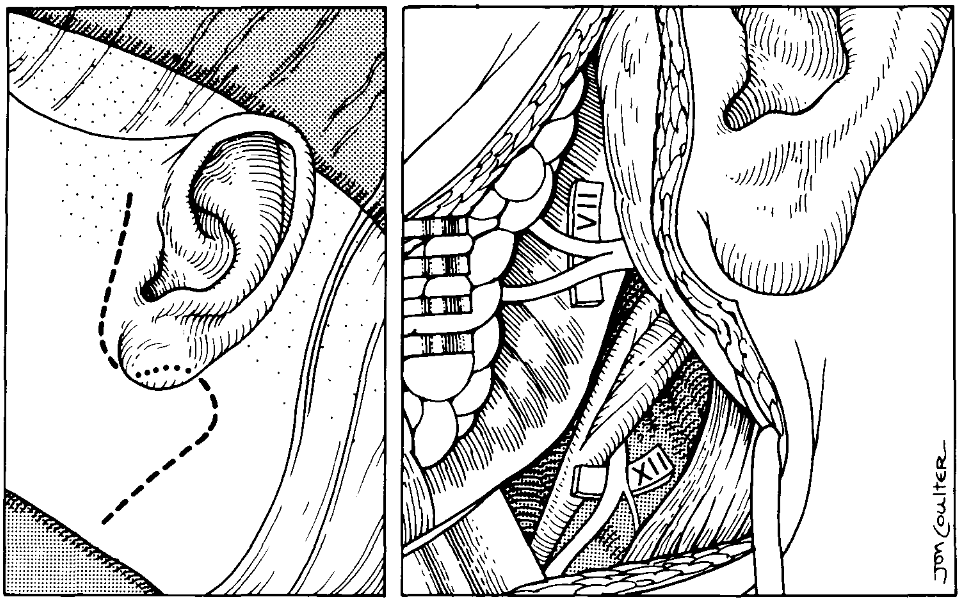

Fig. 1. Surgical technique for cranial nerve 12-7 interpositional jump graft: *left*, parotid incision; *right*, facial nerve and twelfth nerve isolated.

used alone; it is more often combined with other reanimation techniques.

METHODS

Patients

The 14 male and 16 female patients who have undergone the 12-7 jump graft procedure to date ranged in age between 6 and 75 years, with a mean age of 41 years. The causes of facial paralysis are listed in Table 1; most paralysis followed surgery to remove acoustic tumors. The time between injury and performance of 12-7 jump graft surgery ranged between 1 and 48 months.

In the three patients in this series who had bilateral facial palsy, the 12-7 jump graft procedure was performed in two stages. The procedure was performed first on one side of the face, then the patient was monitored for up to 3 weeks for tongue deficit on the side operated on. The second procedure was only performed when adequate tongue function on the first side was assured. Two of these patients were children who had had bilateral facial palsy after surgery to remove tumor at the brainstem, and the third was an adult who had return of tone but still had facial weakness with oral incompetence and weak mass movement 23 months after the onset of bilateral facial palsy following temporal bone fractures.

The facial nerve was intact in this last patient and in one patient who had undergone surgery to remove an acoustic tumor 32 months earlier, with no return of facial function. In the two children who underwent bilateral procedures and in 16 other patients whose results are reported in this paper, the facial nerve was completely interrupted by tumor surgery before the 12-7 jump graft procedure.

Table 1. Causes of facial paralysis treated by 12-7 jump graft procedures

Cause	No. of patients
Posterior fossa-brainstem tumor	
Acoustic tumor	19
Medulloblastoma	3
Astrocytoma	2
Epidermoid cyst	1
Arteriovenous malformation	2
Middle fossa tumor (hemangioma)	1
Extracranial-parotid tumor	
Epidermoid carcinoma	1
Pleomorphic adenoma (recurrent)	1
TOTAL	30

Surgical Technique

The incision for 12-7 jump graft placement is similar to that for a parotidectomy (Fig. 1, *left*). The facial nerve is exposed after the parotid has been mobilized,

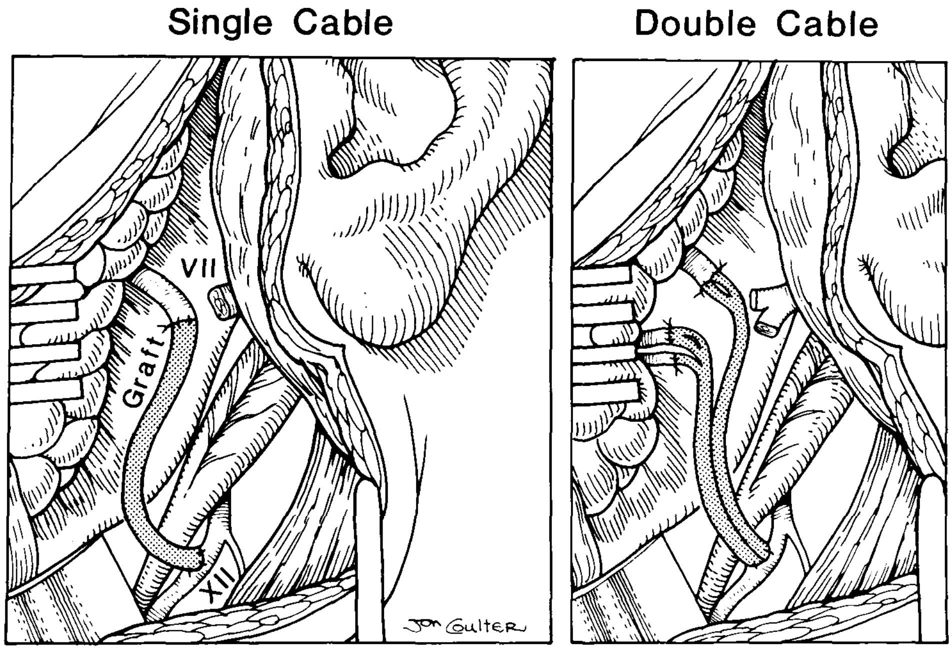

Fig. 2. *Left,* interpositional graft connects partially transected twelfth nerve and main trunk of facial nerve; *right,* double cable graft connects partially transected twelfth nerve to upper and lower divisions of facial nerve just beyond the pes anserinus.

Table 2. *Classification system for reporting results of facial reanimation techniques to manage complete facial nerve transection**

Grade	Definition
I–Superb	Some mimetic (spontaneous emotional) movement Individual movement Complete eye closure and asymmetric smile with maximal effort
II–Excellent	Voluntary movement Spontaneous expression absent Otherwise, same as grade I
III–Good	Mass movement may be present Eye closure complete Asymmetric smile with maximal effort
IV–Fair	Incomplete eye closure and/or very weak mouth movement
V–Poor	Symmetry only Tone intact
VI–Failure	Flaccid Tone lost

*Final results cannot be determined until 24 months after the procedure.

and is followed distally past the pes anserinus. After this is done, the hypoglossal nerve is isolated as it courses between the internal jugular vein and the internal and the external carotid arteries, just beneath the digastric muscle (Fig. 1, *right*). The descendens hypoglossi is identified and a ¼-inch Penrose drain is placed under the hypoglossal nerve and over the descendens hypoglossi. The drain is then pulled taut with a self-retaining retractor to isolate the hypoglossal nerve and pull it toward the surgeon. This important maneuver helps the surgeon when incising the hypoglossal nerve to be sure that the descendens hypoglossi is not confused as contributing to the diameter of the twelfth nerve.

Under the operating microscope, a bevelled incision is made one third to halfway through the hypoglossal nerve, partially transecting the nerve and exposing proximal axons. The hypoglossal nerve is then stimulated electrically proximal to the partial transection to check for functional integrity of the nerve; brisk contraction of the tongue muscles indicates that a significant portion of hypoglossal nerve function has been preserved and correlates well with preservation of tongue function postoperatively.

The facial nerve is now transected at either the main trunk, just beyond the pes anserinus, or at the point at which it branches beyond the parotid.

The interposition graft may be harvested from the great auricular, cervical cutaneous (C2, C3, and C4 complex), or sural nerve. The graft is 5 to 7 cm long, so it more than bridges the distance between the partially transected hypoglossal nerve and the transected

Table 3. Tongue deficit following hypoglossal-facial jump graft compared to classic hypoglossal-facial crossover

Procedure	Tongue atrophy		Swallowing defect		Mastication problems		Speech difficulty	
	No.	%	No.	%	No.	%	No.	%
XII–VII jump	3 of 23	13	1 of 23	4	1 of 23	4	1 of 23	4
XII–VII	(Conley[1])	100	(Pensak et al.[3])	21	(Conley[1])*	10	(Conley[1])*	16

*Mastication and speech difficulties reported by Conley[1] in patients treated by hypoglossal-facial crossover two or more years after facial nerve injury.

Table 4. Recovery of facial muscle function following hypoglossal-facial jump graft compared to classic hypoglossal-facial crossover

Grade	Facial tone and symmetry	Excellent facial movement	Separate eye and mouth movement	Mass facial movement
XII–VII jump	100%	Early, 79%* Late, 38%	10%	0%
XII–VII (Conley[1])	90%	Early, 77%† Late, 41%	10%	100%

*Hypoglossal-facial jump graft. *Early* is considered when the graft is performed within 12 months of facial nerve injury, and *late* when performed 13 months but not later than 48 months after facial nerve injury.
†Hypoglossal-facial nerve anastomosis. *Early* graft performed within 24 months of facial nerve injury, and *late* performed 25 months but not later than 48 months after facial nerve injury.

facial nerve. The epineurium is trimmed from all four cut nerve ends, and one end of the graft is sutured carefully to the proximal cut end of the partially transected hypoglossal nerve and the other end is sutured to the distal facial nerve end (Fig. 2, *left*). Monofilament 10-0 nylon suture material is used, and only enough sutures are placed to achieve accurate approximation without tension.

In some situations, to provide maximal innervation of the facial nerve by hypoglossal nerve axons, a double cable graft may be placed between the two cranial nerves (Fig. 2, *right*).

RESULTS

Between April 1986 and March 1990, we placed a total of 33 grafts in 30 patients. The nerve graft was obtained from the great auricular nerve in 25 instances, the cervical cutaneous nerve in four, and the sural nerve in four. The graft was placed between the partially divided twelfth cranial nerve and connected to the facial nerve either at its main trunk in 24 cases, just beyond the pes anserinus in six cases, or to two or more of the peripheral branches of the facial nerve arising just beyond the parotid in three cases.

The 12-7 jump graft procedure was combined with facial-facial crossface grafting in three patients, with regional reanimation techniques such as implantation of eyelid weights or springs or cartilage in 30 patients, and with temporalis muscle transposition in 21 patients.

Twelfth cranial nerve deficits occurred in three patients operated on early in the study. Two of these three patients experienced partial recovery of twelfth nerve function. The third patient with tongue atrophy had some difficulties with swallowing, mastication, and speech before the twelve-seven procedure because of involvement of multiple cranial nerves III through VII, IX, and X deficits as a result of surgery to repair a brainstem arteriovenous malformation.

Recovery of facial function was noted as early as 3 months and as late as 24 months after 12-7 jump graft placement. Because in some cases the results of surgery were not evident until 2 years after the procedure, the results of this reanimation procedure are reported here only for the 20 patients (23 procedures) with followup of 24 months or longer.

Grading Results

We used the criteria in Table 2 to evaluate results of 12-7 jump graft surgery. None of the patients had (significant) mass movement. In three of the 20 patients, the results of surgery were superb (Fig. 3), as characterized by their ability to produce mimetic facial

Fig. 3. A through **C,** Superb results of 12-7 jump graft placement in a woman with complete right facial paralysis, 3 months after right acoustic tumor surgery: **A,** face in repose; **B,** smiling; **C,** with eyes closed. **D** through **F,** same patient 2 years after hypoglossal-facial nerve interpositional jump graft: **D,** face in repose; **E,** smiling; **F,** with eyes closed tightly and grimacing to demonstrate strong and symmetric facial muscle contractions.

expression and to separate eye from mouth movement. In 13 patients, the results were excellent (Fig. 4). Three patients had fair results of the surgery, including the woman who had experienced bilateral temporal bone fractures who had restored oral competence and relief of hypertonicity. One patient had poor results of surgery.

Timing of Repair

Eleven of the 14 patients who underwent reanimation surgery within 12 months of injury to the facial nerve had superb or excellent results of surgery, and three of eight patients operated on between 13 and 48 months after injury to the nerve had excellent results of surgery.

DISCUSSION

Korte[7] is credited with performing the first successful hypoglossal-facial nerve anastomosis in 1901. While this procedure can decrease the devastating effects of facial nerve deficit, it does so by creating a deficit of the hypoglossal nerve.

Conley[1] has noted that 90% of patients who undergo a classic anastomosis procedure can be expected to have tone and symmetry of the face, and that 77% can be expected to have excellent facial movement, defined as eye closure, the ability to smile (although asymmetrically), and a minimum of mass movement. However, these potential benefits are obtained at the expense of tongue function: some degree of tongue atrophy is pres-

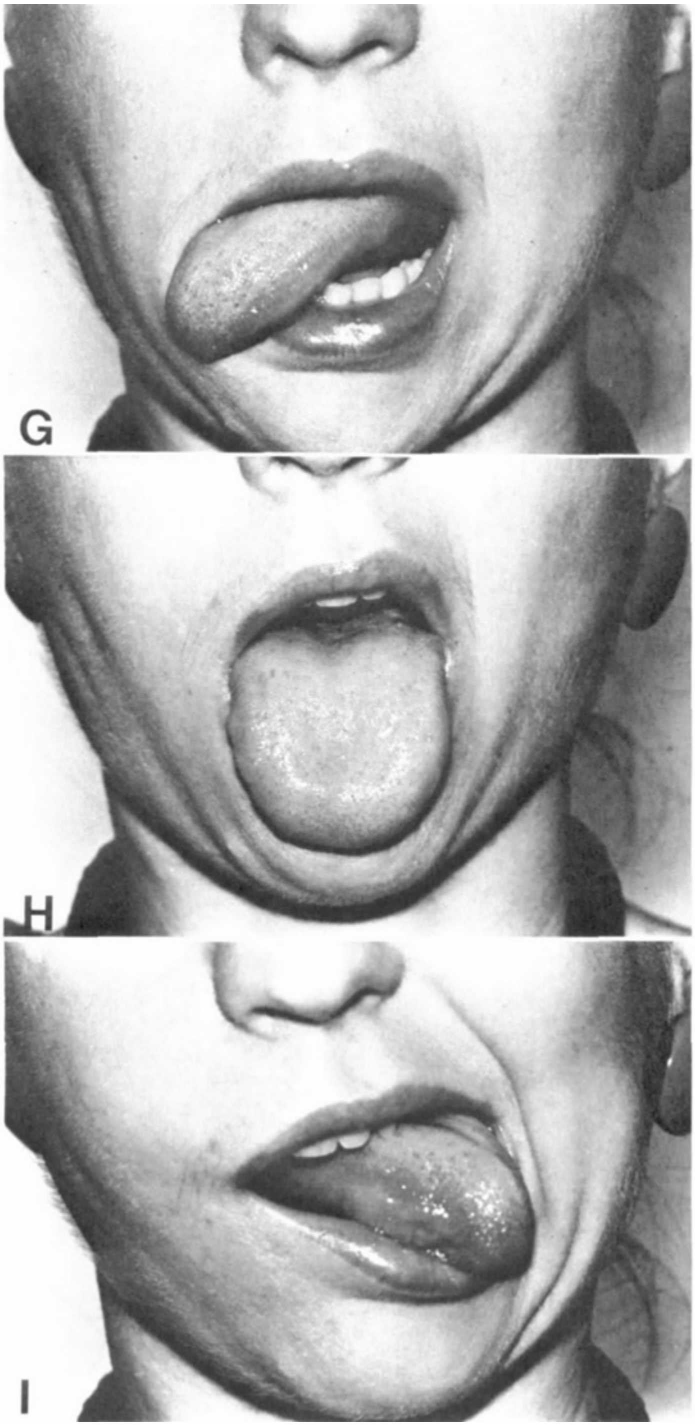

Fig. 3, continued. Same patient, with tongue **G,** pushed to the right; **H,** pushed straight out; **I,** pushed to the left.

ent in every case, functional difficulties are experienced by 74% of patients, and in 21% of patients the swallowing disorder is debilitating.[3]

In addition, the classic anastomosis procedure may not be effective in managing eye problems related to facial paralysis. Pensak et al.[8] found that 21% of their 61 patients who had undergone hypoglossal-facial nerve anastomosis to manage facial paralysis occurring after

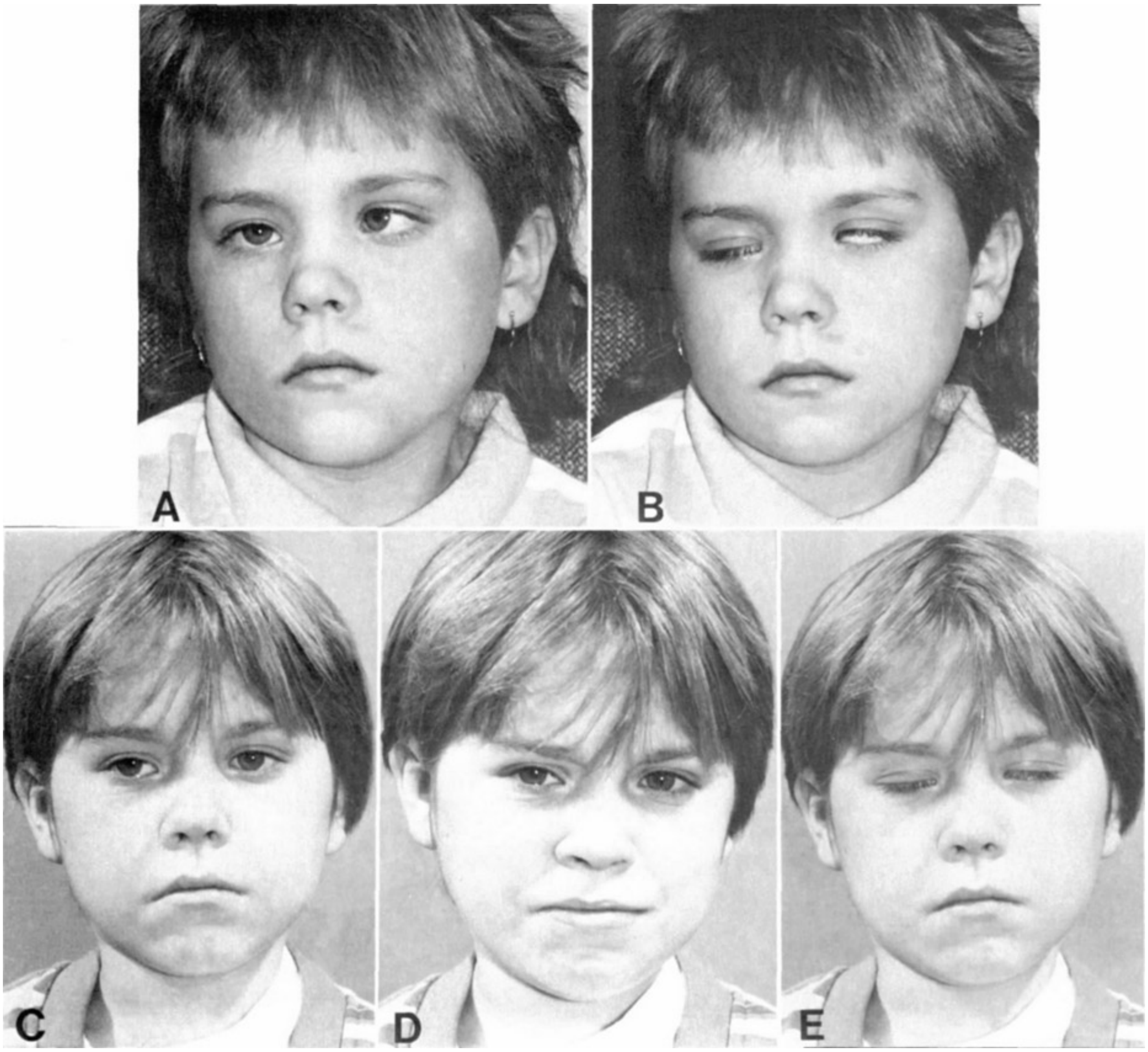

Fig. 4. A and **B,** Excellent results of 12-7 jump graft surgery in an 8-year-old child. Five months after surgery for astrocytoma involving the brainstem, she had bilateral abducens and facial nerve paralysis: **A,** face at rest; **B,** attempting to close eyes and smile. **C** through **E,** same patient. Two years after interpositional hypoglossal-facial nerve jump graft, she has good facial movement: **C,** face in repose; **D,** smiling and pushing the tongue against the palate; and **E,** with eyes closed.

skull base surgery had eye problems. Dryness was a problem in 29% of their cases, decreased visual acuity in 11%, irritation in 17%, and eye pain in 9%. Other problems reported included corneal abrasion and neurotrophic keratitis, and several of their patients had discomfort or limited vision because of a tarsorrhaphy performed to manage these problems. Thus, the patient who has undergone a classic hypoglossal-facial nerve anastomosis may acquire a severe tongue deficit and show no improvement in facial function.

Conley[1] has described using a variation of the classic anastomosis procedure in 15 patients; in three, the descendens hypoglossi was used and in 12 the hypoglossal nerve was split, dissected retrograde, and spliced to the facial nerve. Neither of these variations, however, resulted in useful facial function or avoidance of tongue atrophy and they were abandoned in favor of the original procedure.

Axons in the hypoglossal nerve or any peripheral nerve thread their way through neural tubules in a random, interweaving fashion, so that splitting the nerve (for example, to mobilize a segment) invariably results in transection of axons at multiple points in their courses. This leads to degeneration, not only of the segment split for anastomosis to another nerve, but also of the main trunk of the nerve. These facts probably explain Conley's poor results using split-nerve grafts. Failure of the descendens hypoglossi nerve to reinnervate the denervated facial nerve was probably the result of inadequate numbers of axons.

The 12-7 jump graft procedure avoids causing tongue paralysis and its sequelae by partially incising rather than transecting the twelfth nerve. This leaves enough viable normal uncut ends of hypoglossal nerve axons in healthy condition while sufficient numbers of axons are rerouted to regenerate across the interposition graft to reinnervate the paralyzed face. The three patients operated on early in the study had tongue deficits because the incision into the hypoglossal nerve was greater than intended. The contribution of the descendens hypoglossi to the diameter of the hypoglossal nerve was not appreciated. This complication was avoided in later cases by separation of the descendens hypoglossi from the hypoglossal nerve before transection, as described in this article.

The hypoglossal-facial interpositional jump graft was developed as a result of a personal communication between the senior author (M.M.) and Julia Terzis, MD, who uses a similar procedure to keep distal facial nerve axons viable in patients for whom a staged seven-seven crossover or free muscle transfer is planned.

The indications for placing a 12-7 jump graft are similar to those for classic hypoglossal-facial nerve anastomosis and include (1) complete interruption of the facial nerve, with lack of availability to the central stump for repair, (2) injury occurring ideally less than 2 years previously, and (3) intact extracranial facial nerve and mimetic muscles. In addition, the 12-7 jump graft may be placed when the classic 12-7 procedure is contraindicated: (1) when the hypoglossal nerve is intact on only one side, (2) when the possibility of a tongue deficit must be avoided, (3) when a deficit of the tenth cranial nerve is present, (4) in patients with neurofibromatosis type II, and (5) in patients who have undergone skull base surgery with involvement of multiple cranial nerves.

The results of our 12-7 jump graft procedure and of classic 12-7 surgery as reported by others are presented in Tables 3 and 4. As shown in these tables, our procedure gave comparable results in terms of restoring facial tone and symmetry and useful facial muscle movement. None of our patients experienced mass movement—a problem with the patients who underwent a classic procedure—and our patients were less likely to have problems with swallowing, mastication, and speech than those who underwent a classic procedure. The eye reanimation procedures we performed greatly enhanced our patients' ability to separate eye movement from mouth movement.

Our procedure is not uniformly better than the classic procedure, however. While the 12-7 jump graft procedure preserves tongue function, it results in facial contractions that are not as strong and recovery takes longer when compared with the classic procedure. Further, best results are obtained with our procedure when it is performed within 1 year of facial nerve injury, whereas good results can be obtained with the classic procedure when repair is performed as late as 2 years after injury (Table 4).

We did have excellent results of 12-7 jump graft placement in three of eight patients in our series operated on between 13 and 48 months after facial nerve injury. We believe that in one of these patients, operated on 20 months after facial nerve injury, the excellent results were due more to ancillary reanimation procedures than to the effects of the interposition graft. In a second patient, the continuity of the facial nerve had been preserved, although the nerve was injured during surgery to remove an acoustic nerve tumor. The results of nerve grafting in this case were excellent, probably because of the presence of intact axons and lack of complete collagenization of neural tubules. In the third case, reanimation surgery was performed 15 months after facial nerve injury, and although results are usually best when surgery is performed within 12 months of injury, this recommended time window is not absolute.

In summary, for patients with facial paralysis who cannot tolerate compromise in tongue function, placement of a hypoglossal-facial nerve jump graft may provide significant improvement in facial function when combined with other facial reanimation techniques, without the sacrifice of tongue function that usually accompanies the performance of a classic hypoglossal-facial nerve anastomosis procedure.

REFERENCES

1. Conley J. Hypoglossal-facial anastomosis. In: Brackmann DE, ed. Neurological surgery of the ear and skull base. New York: Raven Press, 1982:93-8.
2. Poe DS, Scher N, Panje WR. Facial reanimation by XI-VII anastomosis without shoulder paralysis. Laryngoscope 1989;99:1040-7.
3. Anderl H. Cross-face nerve grafting—up to 12 months of seventh nerve disruption. In: Rubin LR, ed. Reanimation of the paralyzed face. St. Louis: CV Mosby Co., 1977:241-77.
4. May M. Muscle transposition for facial reanimation: indications and results. Arch Otolaryngol 1984;1:184-9.
5. May M. Gold weight and wire spring implants as alternatives to tarsorrhaphy. Arch Otolaryngol Head Neck Surg 1987;113:656-60.
6. May M, Hoffman DF, Buerger GF, Soll DB. Management of the paralyzed lower eyelid by implanting auricular cartilage. Arch Otolaryngol Head Neck Surg 1990;116:786-8.
7. Korte W. Ein Fal von Nerven Fropfung: Des Nervus facialis auf den Nervus Hypoglossus. Dtsch Med Wochenschr 1903:17.
8. Pensak ML, Jackson CG, Glasscock ME III, Gulya AJ. Facial reanimation with the twelve-seven anastomosis: Analysis of the functional and psychological results. OTOLARYNGOL HEAD NECK SURG 1986;94:305-10.