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Reanimation of the paralyzed face by indirect hypoglossal-facial nerve anastomosis

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Abstract

Background: The results of indirect hypoglossal facial nerve anastomosis with interposition of a free nerve graft, end-to-end to the periferal facial nerve stump, and end-to-side to the hypoglossal nerve are prospectively evaluated. This technique is supposed to overcome loss of hypoglossal function.

Methods: Tongue function in 39 consecutive patients and facial reanimation in 29 patients who completed 24 months follow-up were assessed. Facial nerve function was judged using the House-Brackmann (HB) grading system.

Results: Tongue movements were normal in all operated on patients. Initial facial movements occurred on average 7.5 months postoperatively. The results were graded HB II in 6 (20.9%), HB III in 13 (44.6%), HB IV in 7 (24.1%), HB V in 2 (6.8%) patients, and HB VI in 1 (3.4%) patient. The results were significantly better in young patients and when a short time interval between paralysis and surgery existed.

Conclusions: Indirect hypoglossal-facial anastomosis is the preferred technique in most patients for whom the classical direct hypoglossofacial anastomosis is indicated.

Keywords: Facial paralysis; Reanimation; Hypoglossal nerve; Facial nerve; Nerve graft; End-to-side anastomosis

Preservation of facial nerve function is a major challenge to the surgeon involved in temporal bone and cerebellopontine angle surgery. Despite advances in intraoperative facial nerve monitoring, damage to the facial nerve still occurs. A large variety of surgical techniques are available for facial reanimation, with specific indications. Primary end-to-end anastomosis of the facial nerve stumps reveals the most optimal functional results. To ensure a tensionless facial nerve anastomosis a nerve graft, or facial nerve rerouting, is often needed. End-to-end anastomosis of the intracranial segment is difficult. The facial nerve lacks epineurium at this area. Moreover, the constant pulsation of the brainstem and the flow of liquor in a deep and narrow wound hamper the technique of anastomosis.

When the central stump of the facial nerve is not available for anastomosis, transposition of other cranial nerves to the periferal facial nerve stump is a favored technique. This technique is also indicated when, despite anatomical preservation of the facial nerve, functional recovery did not occur and the mimic muscles are still functional.

Transposition of the hypoglossal nerve and end-to-end anastomosis directly to the facial nerve is a popular, effective, and reliable technique with constant and satisfying results. However, the complete transection of the hypoglossal nerve inevitably results in homolateral paralysis and hemitongue atrophy, which interferes with mastication, speech, and swallowing, particularly when the facial mimic function is less than normal. Moreover, it is emotionally difficult for the patient to sacrifice another cranial nerve after having lost the vestibular, acoustic, and occasionally the lower cranial nerves or trigeminal nerve as a result of cerebellopontine angle surgery. Postoperative difficulty in swallowing that was attributed to tongue dysfunction was a complaint of 10% to 12% of patients [1]. Pensak et al [2] reported in 74% of patients some functional difficulties with eating, of which 21% were debilitating. Hammerschlag [3]

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Table 1
Etiology of facial paralysis

Acoustic neuroma	32
Cerebral infarction	1
Middle ear malignancy	1
Meningioma	2
Supralabyrinthine intracranial cholesteatoma	1
Plexus chorioideus papilloma	1
Parotid gland carcinoma	1
Total number of patients	39

observed both speech and swallowing problems in 45%. In an effort to reduce the adverse effects, Rubin et al [4] interdigitated the midline tongue musculature using a Z-plasty technique. Other techniques used to reduce the post-operative tongue atrophy were anastomosing of the ansa hypoglossi to the distal stump of the hypoglossal nerve or longitudinal splitting of the hypoglossal nerve and performing a split XII-VII anastomosis. All these methods encountered disappointing results [1,5–7].

In 1991 May et al [8] described a modified technique originally conceived by Terzis [9], wherein the hypoglossal nerve and the facial nerve are anastomosed with the interposition of a free nerve graft, end-to-end to the periferal facial nerve stump, and end-to-side to the hypoglossal nerve. The latter is cut in transverse direction for approximately 50%. The procedure is indicated in patients with an intact homolateral hypoglossal nerve, an inaccessible central facial nerve stump, and a preserved periferal facial nerve stump. The mimic muscular activity should have the potency to be reversible. With this technique the authors observed good facial reanimation and rarely observed atrophy or impaired movement of the homolateral side of the tongue.

The purpose of this study was to evaluate the outcome of this technique.

Methods

Patient population

The medical records of all patients who underwent hypoglossal facial nerve anastomosis with interposition of a free nerve graft were reviewed. The clinical material comprised 39 patients. Their ages ranged from 11 to 71 years with a mean age of 47.4 years. All patients presented had a unilateral complete facial nerve paralysis of various duration mostly secondary to acoustic neuroma surgery. The causes of facial nerve paralysis are summarized in Table 1. Tongue mobility and appearance were normal in all patients.

Facial reanimation was assessed in patients who completed 24 months of follow-up. These 29 patients were placed into 3 groups related to the interval between the onset of facial paralysis and the hypoglossal facial nerve graft anastomosis: group 1 with an interval from 4 to 12 months, group 2 with an interval from 12 to 24 months, and group 3 with an interval of more than 24 months. Group 1 comprised 19 patients, 13 women and 6 men; their ages ranged from 11 to 71 years with a mean age of 42.9 years. Group 2 included 6 patients, 5 women and 1 man; their ages ranged from 28 to 62 years with a mean age of 41.9 years. Group 3 consisted of 4 patients, 1 woman and 3 men; their ages ranged from 39 to 62 years with a mean age of 46.7 years (Table 2). For the evaluation of tongue mobility and tongue appearance, all 39 patients were assessed 6 to 24 months after the operation.

Table 2
House-Brackmann (HB) grading and percentage of all patients in each group with hypoglossal-facial nerve anastomosis with free graft interposition in 29 patients at 24 months' follow-up

	HB grading					
	I	II	III	IV	V	VI
Percentage of all patients in each group	NA	20.9%	44.8%	24.1%	6.8%	3.4%
Group I*						
Age (years)	NA	26 49 54	40 57 37 34	71 25	NA	69
Initial facial movement (months)		4 5 9	6 7 8 7	16 8		nil
Age (years)		37 43 48	65 21 21 11	54 54		
Initial facial movement (months)		5 8 6	6 5 4 4	6 11		
Group II†						
Age (years)	NA	NA	62 49 36 38	38 28	NA	NA
Initial facial movement (months)			18 8 6 8	7 4.5		
Group III‡						
Age (years)	NA	NA	62	39	47 39§	NA
Initial facial movement (months)			4	11	11 10	

* Duration of paralysis 3 to 12 months.
† Duration of paralysis 12 to 24 months.
‡ Duration of paralysis >24 months.
§ Full course radiotherapy.
NA = not applicable.

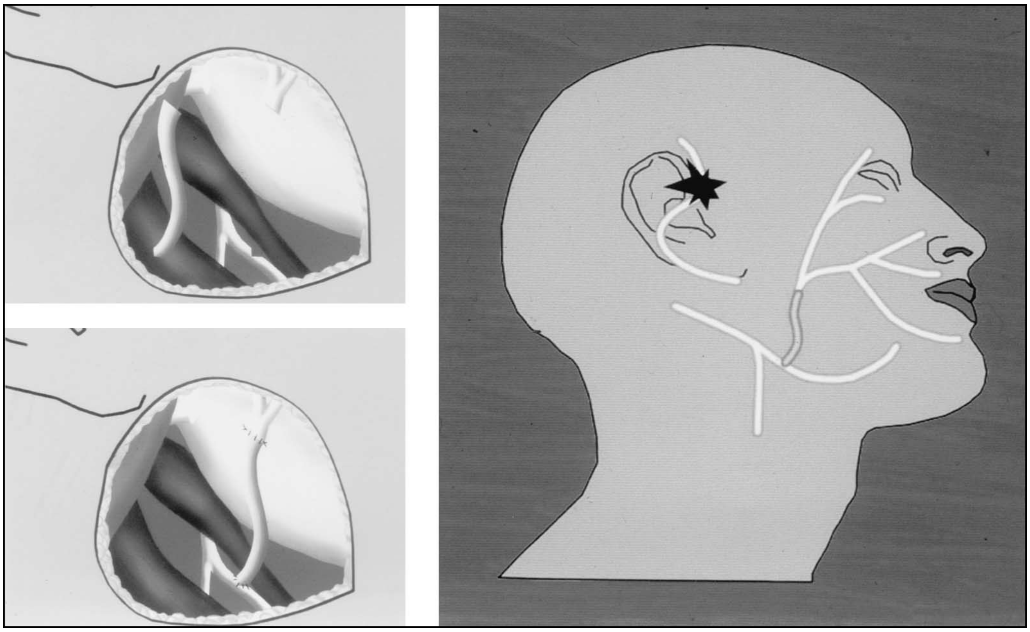

Fig. 1. Schematic representation of the hypoglossal-facial nerve anastomosis with a free nerve graft, end to end to the facial nerve stem and end to side to the hypoglossal nerve.

Surgical technique

The skin incision starts from the insertion of the lobulus slightly curved backward and downward over a distance of approximately 4 cm. The greater auricular nerve is identified and dissected to obtain a graft of about 6 cm. The facial nerve stem is identified and transected near the styloid foramen together with mobilization of the lateral posterior border of the parotic gland. The hypoglossal nerve is identified just beneath the digastric muscle where it crosses the carotic artery bifurcation and internal jugular vein and is followed anteriorly of the ansa hypoglossi. The distal end of the graft of the great auricular nerve is interpositioned end-to-end to the distal stump of the transected facial nerve and the other end is sutured end-to-side to the obliquely incised (up to half its diameter) hypoglossal nerve proximal of the ansa hypoglossi (Fig. 1). Monofilament 10.0 nylon suture material is used for interrupted epineural approximation without tension using the operating microscope. Occasionally a Penrose drain is left in the wound. Usually the patient is discharged the second day following the operation. In the upper eyelid, a gold weight is placed in most patients, occasionally after release of an existing tarsorrhaphy.

Physiotherapy

Most of the patients followed a physiotherapy program as soon as initial movements in the face appeared during tongue movement. The goal of these exercises is to promote facial expression and movements in relation to emotions and expression.

Evaluation of facial reanimation and tongue movement

Facial nerve function was established using the House-Brackmann (HB) facial nerve grading system [10] including tongue movements and excepting upper eyelid gold implantation ($n = 12$), tarsorrhaphy ($n = 2$), or temporal muscle transposition to upper and lower eyelid ($n = 2$). Following the graft anastomosis the patients are evaluated at 3- to 4-month intervals or intercurrent on request, at appearance of initial homolateral facial movements. For reason of comparison of our results with reports in the literature of the indirect graft anastomosis and of the classic direct anastomosis, the HB grading recorded just after 24 months follow-up was taken as reference. Twenty-nine patients were eligible, ie, had a minimal follow-up of 24 months, and all participated in the evaluation. The assessments were performed by two mime physiotherapists (CB, CvdV).

Tongue mobility was evaluated in all patients ($n = 39$) by observing tongue movements in all directions and signs of asymmetry. The tongue appearance was evaluated for signs of atrophy.

Results

Postoperative complications did not occur. The initial anesthesia in the parotic region due to ablation of the greater auricular nerve appeared insignificant to all patients. Tongue mobility was not impaired in any of the 39 patients. In 1 patient a slight asymmetry due to a reduction in size of the homolateral tongue was observed. Twenty-nine of 39 patients completed a minimal follow-up of 2 years at the

Table 3
House-Brackmann facial nerve grading system [10]

Grade	Description	Characteristics
I	Normal	Normal facial function in all areas
II	Mild dysfunction	Gross: slight weakness noticeable on close inspection; may have very slight synkinesis. At rest: normal symmetry and tone
III	Moderate dysfunction	Gross: obvious but not disfiguring difference between two sides; noticeable but not severe synkinesis, contracture, and/or hemifacial spasm. At rest: normal symmetry and tone
IV	Moderately severe dysfunction	Gross: obvious weakness and/or disfiguring asymmetry. At rest: normal symmetry and tone
V	Severe dysfunction	Gross: only barely perceptible motion. At rest: asymmetry
VI	Total paralysis	No movement

time of evaluation, 24 months after the hypoglossal facial nerve graft anastomosis.

All nerve grafts were obtained from the homolateral great auricular nerve. The average graft length in group 1 was 4.6 cm (range 3 to 6 cm, n = 19); in group 2 it was 4.7 cm (range 2.5 to 6 cm, n = 6); and in group 3 it was 4.3 cm (range 3 to 5.5 cm, n = 4).

The average duration of paralysis was 8.2 months (range 3 to 12) in group 1, 16.5 months (range 13 to 24) in group 2, and 30.2 months (range 25 to 36) in group 3 (Table 2).

Improved facial tone and symmetry preceded initial facial movements. The average time to initial facial movements with tongue motion for group 1 was 6.9 months (range 4 to 16, n = 19), for group 2, 8.6 months (range 4.5 to 18, n = 6), and for group 3, 9 months (range 4 to 11, n = 4; Table 2). In all patients facial movements first appeared at 4 to 18 months (average 8.1) and were usually first observed in the midface. One patient in group 1, a 69-year-old man with a complete facial paralysis of 10 months' duration after removal of an acoustic neuroma, actually the fourth-operated patient in the series, never regained any improvement in facial asymmetry or movement. A reexploration was absconded by the patient. A possible explanation could be a disruption of the end-to-side anastomosis due to accidental head movements in the early days after the operation.

The facial reanimation according to the HB grading scale is summarized in Table 3. Basically most patients obtained HB grade III (44.8%), followed by grade IV (24.1%), grade II (20.9%), grade V (6.8%), and grade VI (3.4%).

Ordinal regression analysis showed a significant relation (P <0.006) between duration of facial paralysis and HB grade at 24 months' follow-up, indicating that the longer the duration before operation, the poorer the result. HB grade II was only recorded in group I, where facial paralysis had existed for less than 12 months. In these patients, facial expressions appeared as natural as normal movements.

Table 4
Relation of duration of denervation of mimic musculature and expectation of successful rehabilitation

Duration of denervation	Functional recovery
1 year	Absolutely certain
1 to 2 years	Seemingly certain; recommendable
2 to 3 years	Probable with delay and decrease in functions
3 to 5 years	Increasingly questionable; patient must be notified
5+ years	Improbable; not to be recommended

When the duration of paralysis exceeded 2 years, mimic recuperation was poor. Synkineses were observed in most patients, but no mass movements or gross hypertonia were present. Problems with speech, mastication, or swallowing were not encountered.

Comments

End-to-end anastomosis of the facial nerve stumps either by direct suturing or by interpositioning of a free nerve graft reveals the best functional results. When the central stump is unavailable or when the anatomically preserved facial nerve after cerebellopontine angle or temporal bone surgery has not regained function and the mimic musculature is still viable, transposition of other cranial nerves to rehabilitate the mimic musculature can be considered. The concept of transposition of an alternative motor nerve dates back to 1879, when Drobnik anastomosed the spinal accessory nerve to the facial nerve. Other (cranial) nerves used for transposition are: hypoglossal nerve, facial nerve (cross face anastomosis), phrenic nerve, and glossopharyngeal nerve. The major disadvantage of donor nerve techniques is that a functional nerve has to be sacrificed, leaving the patient with functional loss.

Results of facial nerve reinnervating surgery are related to the duration of the paralysis, ie, the functional state of the mimic musculature. The functional recovery of denervated mimic muscles is time dependent (Table 4) [11]. In addition, the duration of neurotization also has to be considered. The different steps in neurotisation and their timetable are summarized in Table 5 [12,13]. Taking into account both the duration of facial paralysis (ie, the stage of atrophy of the mimic musculature) and the duration of reneurotisation, the decision to perform hypoglossal facial nerve interposi-

Table 5
Time interval of motoric endplate axonization after nerve repair with a graft

Sprouting of cranial stump	±1 month
Passage of nerve suture site	±1 month
Passage of distal nerve (nerve graft)	±1 mm/day
Motoric endplate electromyographic activity	±2 months

tional graft anastomosis is to be taken at latest 1 year after the onset of paralysis, in order to obtain the best results. In the presence of an anatomical intact facial nerve and postoperative facial paralysis, nerve function usually showed signs of recovery within 12 months after acoustic neuroma surgery [14,15]. One may argue that facial nerve regeneration may take up to 18 months before any significant sign of recovery is noted. However, it is questionable if results of recovery will appear as good as with hypoglossal facial nerve graft anastomosis performed at around 12 months after injury, in the absence of clinical and electromyographic signs of recovery. When paralysis lasts more than 2 years, the atrophy of the mimic musculature has progressed so far that other surgical techniques than facial nerve reinnervating procedures have to be considered.

The transposition of the hypoglossal nerve end to end directly to the facial nerve stem is a popular technique with constant and satisfying results. Reinnervation occurs between 6 and 12 months. About 70% of patients obtain fair results. Hypertonia and spastic contractions occasionally give clinical problems. The frontal muscle regains function in about 8% of patients. In about 25% of patients emotional mimic expression can be observed. Most patients can be classified as “good” or as HB grade III [3,11].

The HB grading system adapted by the Facial Nerve Disorder Committee of the American Academy of Otolaryngology, Head-Neck surgery [10] is applicable to the anatomical intact facial nerve and is not a reference system for techniques to anastomose the hypoglossal nerve to the facial nerve. Classification systems for reporting results of facial reanimation techniques after facial nerve transection have been reported but have not been universally accepted [8,16, 17]. An accurate comparison of results is not possible. To circumvent the poorly defined gradings as good, fair, poor, and so forth [3], we decided to follow the HB grading system, including tongue movements and excepting any eyelid surgery.

The functional sequellae of paralysis and atrophy of the ipsilateral tongue favor the modification described by May et al [8] with a free nerve graft interposition (“jump anastomosis”) end to end to the facial nerve and end to side to the hypoglossal nerve for preservation of tongue function.

Our study confirms the favorable functional results of this technique. Three quarters of our patients achieved HB grade II and III. The results appear at least as good as the classic direct hypoglossal-facial nerve anastomosis [1–3,16, 18] and preserves tongue function. The best results attained patients undergoing surgery within 12 months after facial nerve injury. This was also shown by others using the classical direct end-to-end anastomosis between both nerves [1,11,18]. Experimental research in Guinea pigs revealed that nerve regeneration and rearrangement in central nuclei was better in early hypoglossal facial nerve anastomosis [19].

Hypoglossal nerve deficit occurred in none of our patients. May et al [8] observed postoperative hypoglossal nerve deficits in 3 of 33 hypoglossal facial nerve graft anastomosis patients, of whom 2 experienced partial recovery. Bachmann et al [20] studied magnetic resonance images of the tongue after the classic end-to-end anastomosis and after indirect graft anastomosis of hypoglossal and facial nerve. Complete fatty degeneration was found in the classical procedure and insignificant changes in the graft procedure.

In the present study the recovery of the frontal branch of the facial nerve was poor. This may be related to the observation of Chang and Shen [21], that the frontal branch encloses a relative small number of fibers. However, ineffective function caused by cross innervation of antagonistic muscles in this region and cancelling out each other, a proces called “autoparalysis,” may play a role [22].

We observed less synkinesis with the jump technique in comparison to the classical end-to-end anastomosis. This may be related to the reduced reinnervation. Another explanation could be that the routinely included mime therapy may result in more efficient use of the facial musculature. Synkinesis could be reduced by anastomosing only the inferior facial nerve branch with the interpositional graft [23]. The presumed reduced reinnervation after the hypoglossal facial graft anastomosis may plead for the use of the classic direct end-to-end anastomosis when the area of surgery has been, or will be, exposed to radiotherapy.

Historical note

Körte [24] first published anastomosis of the facial nerve to the hypoglossal nerve in 1904, reporting that during an operation for an infectious petrositis, it was indicated to transect the facial nerve at the styloid foramen. Körte anastomosed the periferal facial stump to the side (German *seitlich*) of the hypoglossal nerve, without interposition of a free nerve graft. Initial facial movements appeared after 6 months. The homolateral tongue became atrophic; however, the initially completely paralyzed hypoglossal nerve regained full activity. It was Ballance and Duel [25] who propagated the complete transection of the hypoglossal nerve in favor of the direct end-to-end anastomosis, referred to as the classic procedure actually incorrectly attributed to Körte.

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