Comparison of End-To-End Descending Hypoglossal-Facial Anastomosis And End-To-Side Hypoglossal-Facial Anastomosis For Facial Paralysis After Vestibular Schwannoma Surgery

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Research Article

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Abstract

Background: We aimed to compare the outcomes of end-to-end descending hypoglossal-facial anastomosis (eeDHFA) and end-to-side hypoglossal-facial anastomosis (esHFA) in patients with complete facial paralysis after vestibular schwannoma (VS) surgery.

Methods: This retrospective study included 52 patients with complete nerve damage identified during previous VS removal or on electromyography during follow-up. Postoperative facial palsy was evaluated using the House-Brackmann (HB) facial nerve grading system. Postoperative hemiglossal atrophy and swallowing were assessed using Martins' grading system and the water-swallowing test, respectively. Hoarseness was also recorded if present.

Results: The median time from VS resection to anastomosis was not significantly different between the two groups (p=0.062). The median follow-up time showed no significant differences between groups (eeDHFA: 17 months; esHFA: 14 months; p=0.446). We found no significant differences in the number of favourable (HB I-III) or unfavourable (HB IV-VI) outcomes for facial nerve function in the last follow-up (p=0.924). Only one patient from each group developed hemi-tongue myoparalysis. No patient experienced swallowing dysfunction or hoarseness.

Conclusions: We concluded that eeDHFA is as effective as esHFA as a surgical method for the treatment of facial palsy after VS surgery. Since eeDHFA represents a simple technique for facial reanimation, it could therefore be considered as an alternative surgical option for patients affected by complete facial paralysis after VS surgery.

Background

Facial paralysis is a severe complication of vestibular schwannoma (VS) surgery and significantly impacts quality of life. Hypoglossal-facial nerve anastomosis is one of the most effective methods for facial paralysis treatment after VS surgery [1–6]. However, classic hypoglossal-facial nerve anastomosis involves complete hypoglossal nerve transection, which leads to speech, masticatory and swallowing dysfunctions [7–10]. In the past three decades, several improved procedures have been developed to preserve tongue function, including end-to-side hypoglossal-facial anastomosis (esHFA), masseteric-facial nerve anastomosis, end-to-end facial nerve anastomosis with interposition graft, and split hypoglossal-facial anastomosis [2, 4–6, 11–18]. Therefore, surgeons have gradually abandoned the use of classic hypoglossal-facial nerve anastomosis. Some studies have reported satisfactory results for facial reanimation after esHFA [10, 14, 19]. Recently, Samii and colleagues also reported that recovery of facial nerve function after esHFA was similar to that obtained after classic end-to-end hypoglossal-facial anastomosis, with the added advantage of avoiding the complication of hemiglossal atrophy [4].

The effectiveness of end-to-end descending hypoglossal-facial anastomosis (eeDHFA) for restoring facial function is controversial. Some reports indicated that a mismatch in the fascicular surface area between the descendens hypoglossi and the facial nerve could cause anastomotic failure [20, 21]. However, other authors have reported that use of the descendens hypoglossi as donor led to good recovery [2, 22, 23].

To the best of our knowledge, no studies have compared the efficacy of eeDHFA and esHFA. Therefore, in the present study we aim to report our experience with eeDHFA and to present a direct comparison between the outcomes of eeDHFA and esHFA. We also evaluated postoperative morbidities in tongue function.

Methods

Patient population

We retrospectively enrolled 52 consecutive patients who underwent anastomosis between October 2010 and May 2021 for the treatment of complete facial paralysis after VS surgery. All patients had complete nerve damage identified during previous VS removal or on electromyography of the facial muscles during follow-ups. In each case, the interval between VS surgery and anastomosis was less than two years. All procedures were performed by two senior neurosurgeons. The exclusion criteria were: complete facial paralysis caused by other diseases or an interval of more than 2 years between VS surgery and anastomosis. The patients were assigned to either the eeDHFA or the esHFA group based on the ratio of the descendens hypoglossi diameter to the facial nerve diameter as measured during surgery (eeDHFA group: ratio ≥1:2; esHFA group: ratio <1:2). The Capital Medical University Xuanwu Hospital Research Ethics Committee approved the study design (2019-075). Informed consent was obtained from all individual participants included in the study.

Evaluation of nerve function

Pre- and postoperative facial nerve function was evaluated and graded from I to VI according to the House-Brackmann (HB) facial nerve grading system [24]. We designated postoperative facial nerve function as favourable (grades I, II and III) or unfavourable (grades IV, V and VI) based on facial function recovery. The degree of tongue atrophy was evaluated and graded from I to IV according to Martins' grading system [10], and swallowing function was assessed using the water-swallowing test [25]. Two senior neurosurgeons performed all nerve function evaluations.

Surgical procedure

The patients were placed under general anaesthesia in the supine position, with the head turned 30 degrees to the contralateral side of the planned procedure site. An oblique linear skin incision was made, starting from the inferior border of the external auditory meatus and extending obliquely along the anterior border of the sternocleidomastoid muscle. To expose the descending hypoglossal nerve branch, the skin incision was made 2 cm inferior to the angle of the mandible (Fig. 1a). The greater auricular nerve, which provides sensory innervation to the earlobe and the mandible angle, was dissected and preserved (Fig. 1b).

The hypoglossal nerve was identified using a nerve stimulator and dissected at the level of the carotid artery bifurcation. Then, the descending hypoglossal nerve branch was identified and exposed distally by 2 cm or more (Fig. 1c and d). Following this, the facial nerve was dissected at the stylomastoid foramen.

eeDHFA was performed when the ratio of the descendens hypoglossi diameter to the facial nerve diameter was 1:2 or greater (Fig. 2). The facial nerve was reflected caudally toward the hypoglossal nerve under the digastric muscle. Adequate release of the descending hypoglossal branch was crucial to reach the facial nerve stump and perform a tensionless anastomosis. The hypoglossal and facial nerves were then connected end-to-end using four 10-0 nylon epineural sutures.

esHFA was performed when the ratio of the descendens hypoglossi diameter to the facial nerve diameter was less than 1:2. A partial mastoidectomy was performed to expose and release the facial nerve in the fallopian canal up to its external genu. Then, the proximal end of the hypoglossal nerve was cut in half. After that, the distal end of the facial nerve stump was stitched to the hypoglossal nerve using four 10-0 nylon epineural sutures.

Statistical analyses

All statistical analyses were performed using SPSS, version 26.0 (IBM Corp., Armonk, New York, US). The Kolmogorov–Smirnov test was used to test for normality; age was normally distributed and was evaluated using Student's t-test. Interval time and follow-up were not normally distributed and were evaluated using the Mann-Whitney U test. Categorical variables were analysed using the Chi-square test. p values less than 0.05 were considered significant.

Results

In our cohort, 32 patients underwent eeDHFA (female, n=21; average age, 45.66±13.190 years; age range, 21–73 years), and 20 underwent esHFA (female, n=15; average age, 45.05±12.202 years; age range, 28–65 years). There was no significant difference in the median time elapsed from VS resection to anastomosis between the eeDHFA and esHFA groups (2.0 months and 0.5 months, respectively; p=0.062). Furthermore, there were no significant differences between the median follow-up times (eeDHFA group, 17.0 months; esHFA group, 14.0 months; p=0.446) (Table 1). Remarkably, there were no significant differences between the esHFA and eeDHFA groups in the proportion of patients that exhibited favourable and unfavourable recovery of facial function (p=0.924) (Table 2).

Table 1
Baseline data of patients who underwent end-to-end descending hypoglossal-facial anastomosis and end-to-side hypoglossal-facial anastomosis

	eeDHFA (n=32)	esHFA (n=20)	P-value
Sex (%)			0.476
Female	21 (65.6)	15 (75.0)	
Male	11 (34.4)	5 (25.0)	
Age (year)			
Mean (SD)	45.66 (13.190)	45.05 (12.202)	0.869
Side (%)			0.264
Left	11 (34.4)	10 (50.0)	
Right	21 (65.6)	10 (50.0)	
Interval time (months)			
Median (P_{25}, P_{75})	2.0 (0.6, 4.0)	0.5 (0.5, 2.0)	0.062*
Follow up (months)			
Median (P_{25}, P_{75})	17 (9.25, 44.75)	14 (10.50, 26.25)	0.446*
*Mann-Whitney U test			
HB: House-Brackmann; FN: facial nerve; eeDHFA: end-to-end descending hypoglossal-facial anastomosis; esHFA: end-to-side hypoglossal-facial anastomosis; SD: standard deviation			

Table 2
House-Brackmann grade details of patients who underwent end-to-end descending hypoglossal-facial anastomosis and end-to-side hypoglossal-facial anastomosis

HB grade	eeDHFA (n=32) (%)	esHFA (n=20) (%)	P-value
Favorable (I-III)	22(68.8)	14(70.0)	0.924
II	7(21.9)	6(30.0)	
III	15(46.9)	8(40.0)	
Unfavorable (IV-VI)	10(31.2)	6(30.0)	
IV	8(25.0)	6(30.0)	
V	2(6.2)	0(0)	
HB: House-Brackmann; eeDHFA: end-to-end descending hypoglossal-facial anastomosis; esHFA: end-to-side hypoglossal-facial anastomosis			

In all patients, the preoperative facial nerve function HB grade was VI. Table 2 shows the HB grade distribution at the last follow-up in the eeDHFA (grade II, n=7; grade III, n=15; grade IV, n=8; grade V, n=2) and esHFA (grade II, n=6; grade III, n=8; grade IV, n=6) groups. Only one patient in the eeDHFA group and one in the esHFA group experienced hemi-tongue myoparalysis. None of the patients experienced swallowing dysfunction or hoarseness, neither after the operation nor during the follow-up period.

Case 1

A 34-year-old man presented with a one-month history of facial paralysis after right VS surgery. With a preoperative facial nerve function of HB grade V (Fig. 3a, b, and c), the patient required facial nerve repair because the nerve was not anatomically preserved during VS surgery. Intraoperatively, the ratio of the descendens hypoglossi diameter to the facial nerve diameter was observed to be greater than 1:2 (Fig. 3d and e), and we performed eeDHFA. One year postoperatively, the HB grade was II, the hypoglossal nerve function was normal (Fig. 3f, g, and h), and the patient had no hoarseness or dysphagia.

Case 2

A 28-year-old man underwent left VS resection without anatomical preservation of the facial nerve at our hospital. Ten days later, our preoperative physical examination showed HB grade V facial paralysis (Fig. 4a, b, and c). Intraoperatively, we found a small fascicular area on the surface of the descendens hypoglossi. Therefore, we performed esHFA (Fig. 4d and e). Six months later, facial nerve function was determined to be HB grade II, and hypoglossal nerve function was normal (Fig. 4f, g, and h). The patient did not experience dysphagia or hoarseness postoperatively or during the follow-up period.

Discussion

We compared the efficacy of eeDHFA and esHFA for the treatment of facial nerve injury during VS surgery and found that the outcome did not differ significantly between the two procedures. VS surgical techniques have improved with the rapid development of minimally invasive neurosurgery technology and electrophysiological monitoring. However, facial paralysis after VS surgery is common, and managing severe complications is still challenging. Hypoglossal-facial nerve anastomosis is one of the most effective methods for facial paralysis treatment after VS surgery [6]. However, the traditional hypoglossal-facial nerve anastomosis technique involves complete transection of the hypoglossal nerve, leading to severe hemiglossal atrophy and speech, masticatory, and swallowing dysfunctions. Therefore, surgeons still need to develop new procedures capable of relieving the symptoms of facial paralysis and reducing the corresponding complications after nerve anastomosis to improve the patient’s quality of life.

Several improved surgical methods have been developed to avoid the complications associated with classic facial nerve and hypoglossal nerve trunk end-to-end anastomosis, including esHFA, masseteric-facial nerve anastomosis, end-to-end facial nerve anastomosis with interposition graft, and split hypoglossal-facial nerve anastomosis [2, 4–6, 11–18]. However, the key feature of an improved technique is that the procedure minimizes disruption of the hypoglossal nerve and other nerve functions, allowing for effective facial reanimation [26]. Unfortunately, some of the surgical methods listed above are unlikely to achieve this outcome. The function of masseteric and interposition graft nerves is damaged during masseteric-facial nerve anastomosis and end-to-end facial nerve anastomosis with interposition graft. Furthermore, the interposition nerve graft needs two connecting points, which could reduce axon regeneration [11, 15]. Split hypoglossal-facial anastomosis causes injury to nerve axons [27], and splitting the hypoglossal nerve is technically difficult [26].

Many studies have demonstrated the effectiveness of esHFA [7, 10, 14, 19, 28–32]. Notably, a study by Samii and colleagues reported that the outcomes for facial function after esHFA and after classic end-to-end hypoglossal-facial nerve anastomosis were comparable, and that postoperative hemi-tongue atrophy could be avoided when esHFA was performed[4]. However, this procedure is technically difficult, requiring surgeons to drill into the mastoid process and expose the mastoid part of the facial nerve.

The descending branch of the hypoglossal nerve, also known as the superior root of the ansa cervicalis, originates from the anterior branch of the first cervical nerve and accompanies the hypoglossal nerve to form the ansa cervicalis with fibers from the anterior branches of the second and third cervical nerves (the lower root of the ansa cervicalis). The main function of the ansa cervicalis is to lower the hyoid bone and to assist in swallowing and phonation. Owing to the compensatory effect of the inferior root of the ansa cervicalis, there was no obvious dysfunction after transecting the descending branch of the hypoglossal nerve. Moreover, the descending branch of the hypoglossal nerve is located in the surgical field during nerve anastomosis, making it easy to access. Therefore, this branch is a good choice for donor [23].

Transection of the main trunk of the hypoglossal nerve leads to unilateral lingual muscle atrophy and may result in dysphagia and difficulty in articulation and mastication [33]. Use of the descending branch of the hypoglossal nerve as donor avoids these problems, potentially improving the quality of life of the patient. However, early reports suggested a poor outcome after eeDHFA [2, 12, 20]. Samii and Matthies reported that matching the diameters of the donor and recipient nerves is a key factor for successful nerve reanimation [34]. Thus, some authors have suggested that the poor outcomes are the result of the significant mismatch in the fascicular surface area between the descendens hypoglossi and facial nerve, given that the former has only 20% of the fascicular surface area of the latter. This mismatch limits the use of the descendens hypoglossi for facial reanimation [2, 12, 20]. Further, some authors believe that the caudal-to-rostral direction of nerve impulse transmission in the superior root of the ansa cervicalis explains the poor results of eeDHFA for the treatment of facial palsy sequelae[6]. However, others have reported good outcomes despite using the descendens hypoglossi as the donor nerve [2, 22, 23].

We performed eeDHFA when the diameter of the descending branch of the hypoglossal nerve was more than half of the facial nerve diameter. After follow-up, the outcomes for eeDHFA were as good as those for esHFA. In addition, surgical complications were avoided by performing eeDHFA. Only one patient from each group experienced hemi-tongue myoparalysis in this study. None of the patients developed postoperative dysphagia or hoarseness. Facial nerve anastomosis of the descending branch of the hypoglossal nerve is an improvement on facial nerve-hypoglossal nerve trunk end-to-end anastomosis, as the former preserves the hypoglossal nerve trunk and restores the facial nerve. The procedure could substantially reduce the incidence of complications, including unilateral tongue muscle atrophy and dysphonia. Moreover, it is a simple and efficient method for facial reanimation.

Given the impact of Wallerian degeneration, most authors concluded that the time elapsed between facial nerve injury and anastomosis has an important effect on facial reanimation outcomes [8, 10, 19, 34–36]. Darrouzet and colleagues reported that the recovery time for facial nerve function was extended in patients with a prolonged interval between facial injury and reanimation [8]. Further, some authors suggest that muscle transfers, transposition or neuromuscular pedicle grafts, and facial nerve repair should all be performed when paralysis has been present for more than 2 years, due to the progression of facial muscle atrophy [37–39]. Importantly, most authors report that facial repair should be performed within 2 years to ensure good recovery of facial nerve function [4, 14]. We believe that the effect of surgical timing on facial recovery is minimal when the pre-repair interval is less than 2 years. In addition, it is important to note that the myelinated axons of the injured facial nerve are likely to degenerate and decrease in number. It has been reported that the diameter of an intact facial nerve is approximately 61.5% of the normal hypoglossal nerve diameter, whereas this figure becomes less than 50% in case of nerve injury [26]. We believe that the matching between the descendens hypoglossi and facial nerve was an important factor behind the outcomes we observed in this study.

The eeDHFA and esHFA procedures are effective for the treatment of facial paralysis after VS removal and result in improved facial symmetry, facial muscle tension, and motor function. Samii and colleagues reported that the best results were observed in patients with VS, while the worst outcomes occurred in the "other pathology" group (p=0.038) [4]. Therefore, further research is needed to investigate the efficacy of eeDHFA in patients with diseases other than VS. Additional studies are also required to determine the optimal diameter of the descending branch of the hypoglossal nerve and to clarify the mechanism of nerve reanimation. In addition, the data of this study were collected retrospectively from records, and the sample was small. Thus, the efficacy of eeDHFA should be studied further in a prospective study.

Conclusions

In summary, our results indicate that eeDHFA is an effective surgical method for the treatment of facial paralysis after VS surgery, with outcomes that are comparable to those of esHFA. The procedures were equally efficient for the improvement of facial nerve function. Moreover, eeDHFA represents a simple technique for facial reanimation. eeDHFA should therefore be considered as an alternative surgical treatment for facial paralysis after VS removal.

Declarations

Ethics approval and consent to participate: All procedures performed in studies involving human participants were in accordance with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. It was also approved by the ethical committee of Xuanwu Hospital, Capital Medical University. Informed consent was obtained from all individual participants included in the study. Additional informed consent was obtained from all individual participants for whom identifying information is included in this article.

Consent for publication: We have obtained the written informed consent for the publication of the details, images and facial photos from each individual.

Availability of data and materials: The datasets used and/or analyzed during the current study are publicly available from the corresponding author. All data generated or analyzed during this study are included in thisarticle.

Competing interests: The authors declare that there is no conflict of interest.

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Authors' contributions: GS and YZ contributed to the conception of this study and wrote the manuscript. YF, XW, and ML collected the cases and analysed the data. HG, GC, and YB evaluated the House-Brackmann grade of pre- and post-operative patients. JL contributed to the discussion part and revised the manuscript.

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Figures

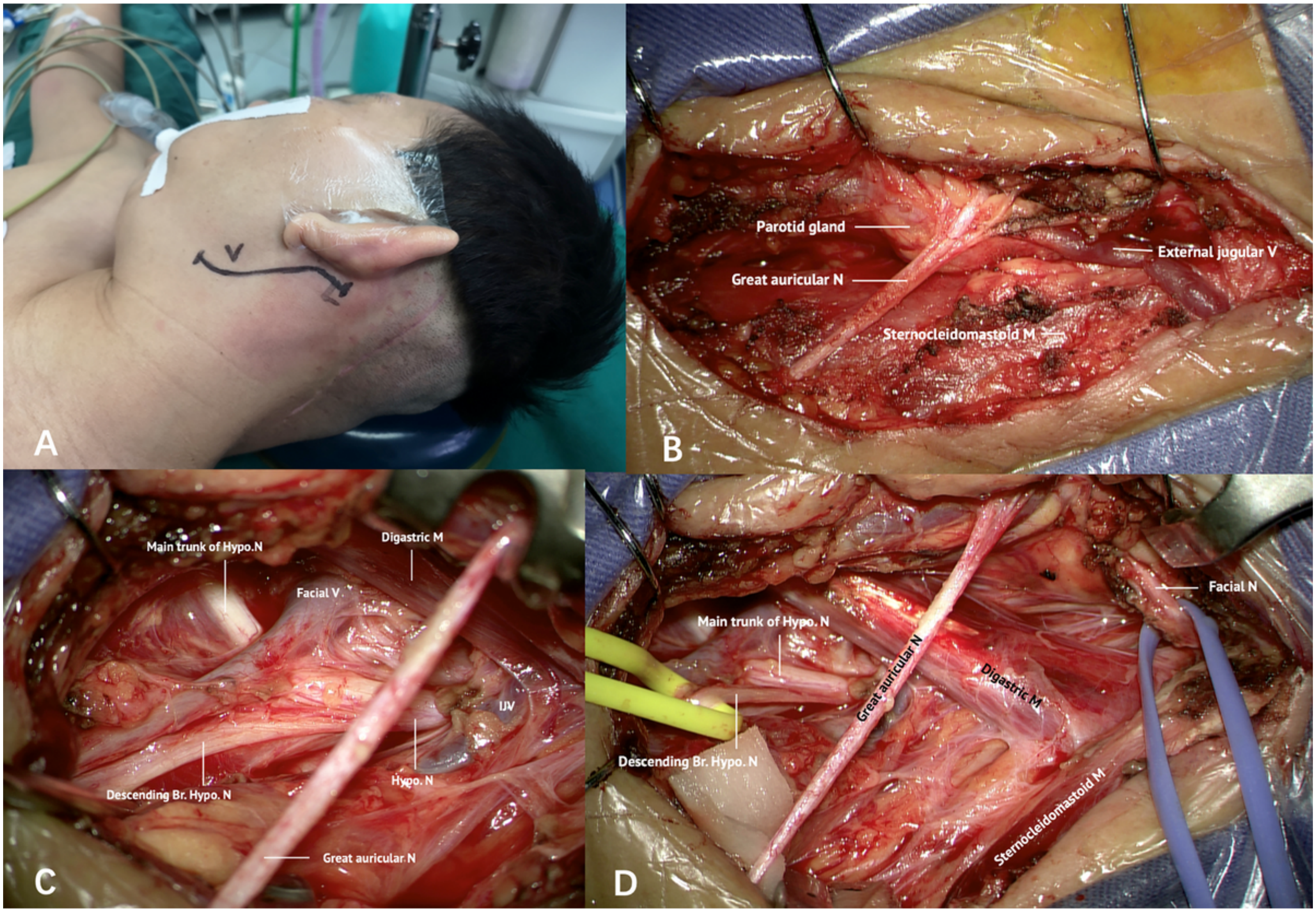

Figure 1

Incision position and intraoperative views of anastomosis. **a** The position of the skin incision made posterior to the ear and extending down to the upper neck is shown. **b** The subcutaneous tissue, fascia, and platysma were divided, and the sternocleidomastoid muscle and great auricular nerve were visualized. **c** The exposure of the main trunk of the hypoglossal nerve and descendens hypoglossi, which was exposed as distally as possible, is shown. **d** The positions of the facial nerve, the main trunk of hypoglossal nerve, and descendens hypoglossi, and the digastric and sternocleidomastoid muscles are shown.

Nerve: N; Muscle: M; Vein: V; Branch: Br; Hypoglossal: Hypo.; Internal jugular vein: IJV.

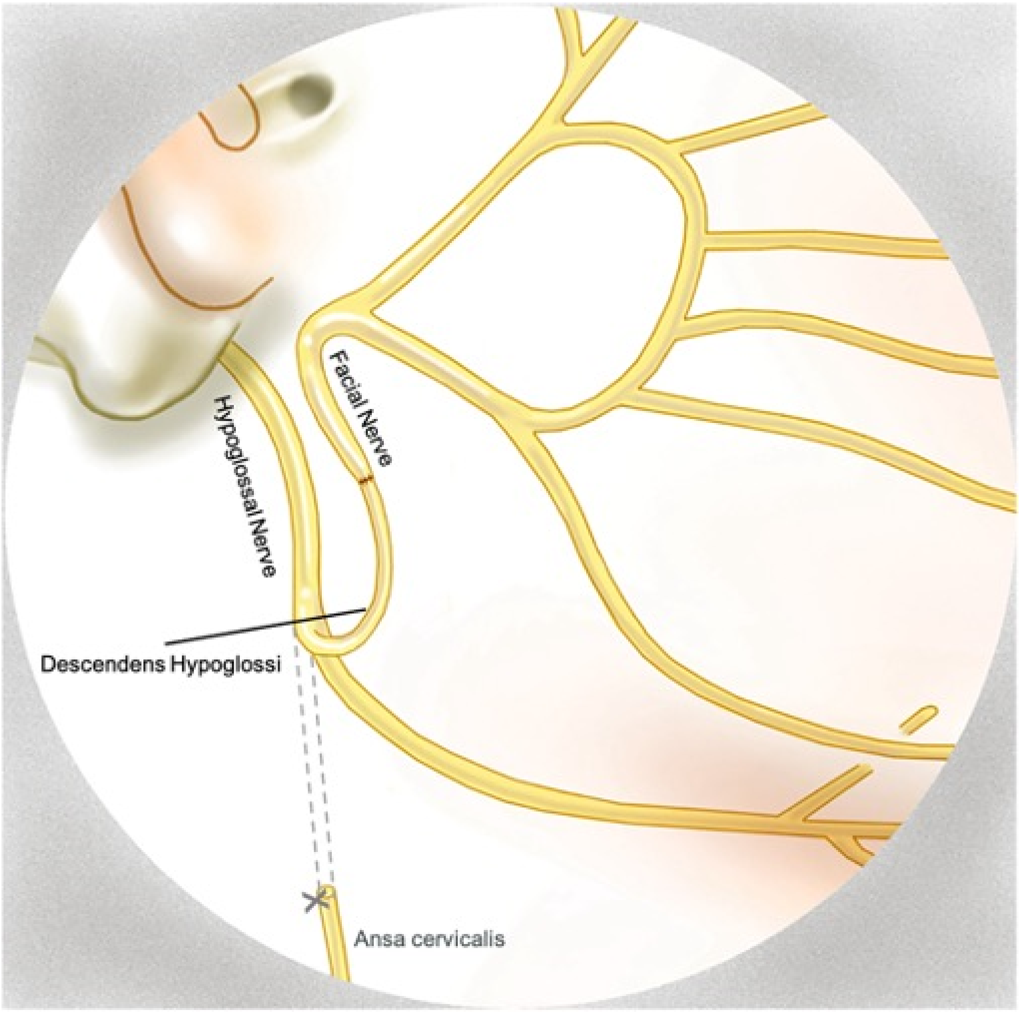

Figure 2

Illustration depicting end-to-end descending hypoglossal-facial anastomosis.

Figure 3

a, b, c Preoperative photographs showing representative HB grade V facial nerve function. **d** Intraoperative photograph of the end-to-end descending hypoglossal-facial anastomosis showing the exposed hypoglossal nerve (red arrow), descendens hypoglossi (blue arrow), and the greater auricular nerve (yellow arrow); **e** photograph showing that the ratio of the descendens hypoglossi (blue arrow) diameter to the facial nerve (red arrow) diameter was in this case higher than 1:2. **f, g, h** Photographs taken one year after end-to-end descending hypoglossal-facial anastomosis showing improved facial nerve function (HB grade II) and normal tongue function.

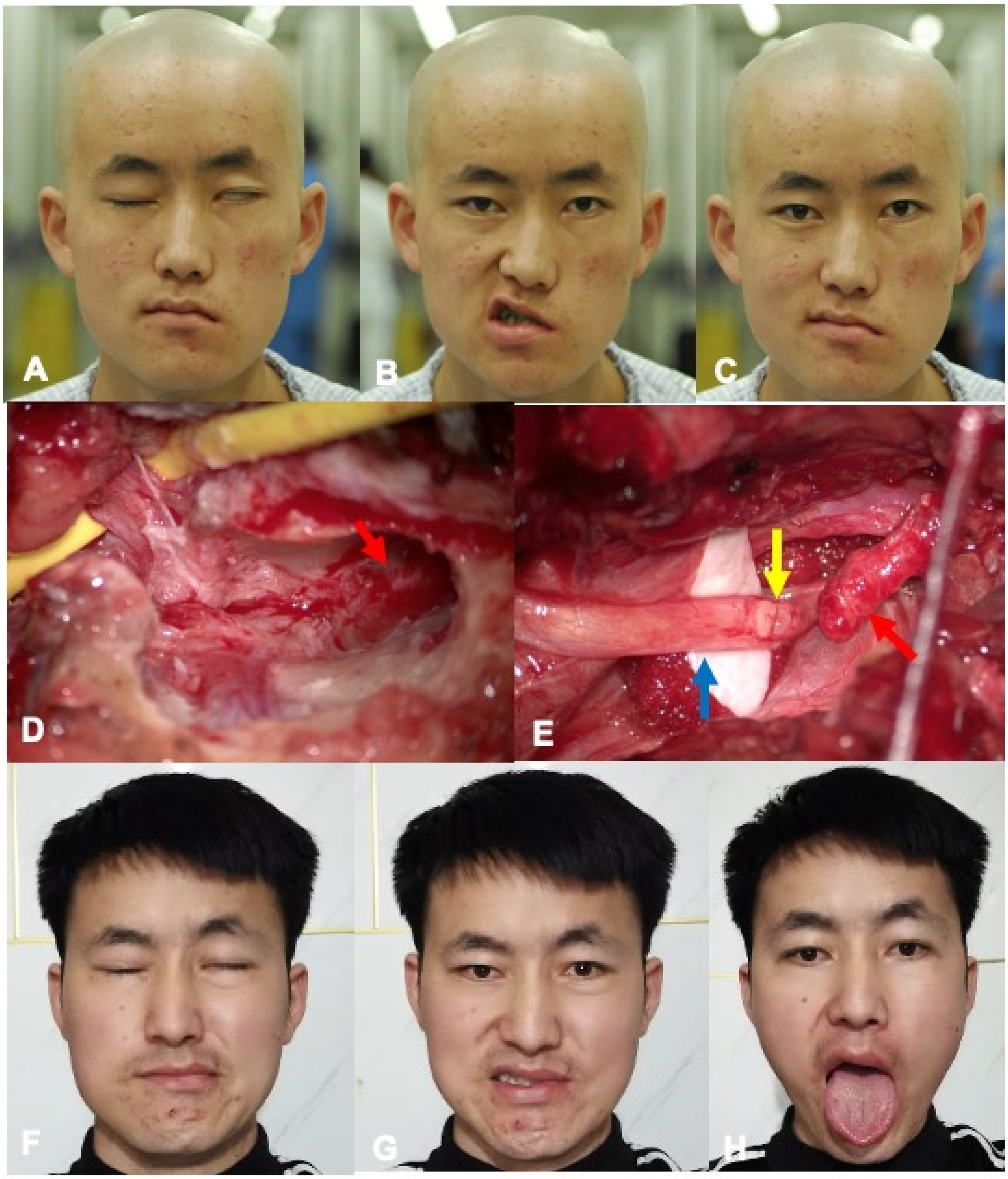

Figure 4

a, b, c Preoperative photographs showing HB grade V facial nerve function. **d** Intraoperative photograph of end-to-side hypoglossal-facial anastomosis showing the partial mastoidectomy exposing the facial nerve in the fallopian canal up to its external genu (red arrow). **e** photograph showing how the proximal end of the hypoglossal nerve (blue arrow) was cut in half (yellow arrow), and end-to-side anastomosis of the facial (red arrow) and hypoglossal nerves was performed. **f, g, h** Photographs taken 6 months after end-to-side hypoglossal-facial anastomosis showing improved facial nerve function (HB grade II) and normal tongue function.