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Hypoglossal–facial crossover in facial-nerve palsy: pure end-to-side anastomosis technique

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SUMMARY. Hypoglossal–facial crossover is the most popular method of reconstructing the facial nerve in facial palsy resulting from proximal facial-nerve injury near the brainstem. Conventional hypoglossal–facial crossover involves performing a partial hypoglossal-nerve section or incision and an interpositional nerve graft to bridge the gap between the two nerves, which sometimes results in hemiglossal atrophy and its sequelae. Furthermore, the nerve graft may delay recovery and make facial reanimation weak. To solve these problems, we attempted to perform 'pure end-to-side anastomosis' (without section of the hypoglossal nerve) between the hypoglossal and facial nerves in four patients with facial palsy. In two patients (group I) a sural-nerve graft was used to bridge the gap between the two nerves. In the other two patients (group II) the intratemporal facial nerve was mobilised to the neck and one tension-free end-to-side anastomosis was performed. Facial symmetry and tone at rest were restored in all cases. Facial reanimation was achieved in group II after 8 months. Despite the small number of cases, we believe that the technique of hypoglossal–facial crossover with 'pure end-to-side anastomosis' and mobilisation of the intratemporal facial nerve can decrease donor-nerve morbidity in facial-nerve rehabilitation. © 2002 The British Association of Plastic Surgeons

Keywords: hypoglossal–facial crossover, end-to-side anastomosis, mobilisation of the intratemporal facial nerve.

In cerebello-pontine angle surgery, development of neurosurgical microscopic techniques has made it possible to maintain the anatomical integrity of the facial nerve, but its function is not always preserved, necessitating facial-nerve reconstruction. In addition, certain tumours, such as facial neuromata, may necessitate resection of the proximal portion of the facial nerve near the brainstem, where it is impossible to repair the facial nerve primarily or to bridge the gap with a nerve graft.[1] In these cases, if there is no atrophy or fibrosis of the facial musculature, hypoglossal–facial crossover can be used to provide alternative cortical input through the distal remnant of the facial nerve in order to revive facial expression.[2]

Since Körte reported the classic hypoglossal–facial crossover in 1901, the technique has been modified to avoid hemiglossal atrophy and to achieve more effective results. Conventional techniques of hypoglossal–facial crossover involve a partial section or an incision of the hypoglossal nerve at the anastomotic site, and the insertion of a nerve graft to bridge the gap between the two nerves. The damage to the hypoglossal nerve may result in refractory hemiglossal atrophy, and the interpositional nerve graft leads to weak facial reanimation and delayed recovery.[3]

We have attempted end-to-side anastomosis without incising the hypoglossal nerve (we call it 'pure' end-to-side anastomosis for comparison with the conventional method) and intratemporal facial-nerve mobilisation for effective hypoglossal–facial crossover with less morbidity.

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Patients and methods

Patients

Between November 1996 and May 1998, we performed pure end-to-side anastomosis in four patients with facial palsy. The facial palsy resulted from a traffic accident (one patient), parotid malignancy (one patient) and resection of acoustic neuromata (two patients) (Table 1).

We divided the patients into two groups. In group I, the two patients underwent pure end-to-side anastomosis with a sural-nerve graft. Their mean age was 43.5 years, and the average follow-up period was 18.5 months. In group II, the other two patients underwent pure end-to-side anastomosis without a nerve graft by mobilisation of the intratemporal facial nerve. Their mean age was 26.5 years, and the average follow-up period was 15.5 months.

After hypoglossal–facial crossover, the patients were trained to swallow or push the tongue against their teeth to help facial reanimation.

Surgical procedure

Group I. A postauricular incision was extended 2–5 cm downward along the margin of the mandibular angle. The facial-nerve trunk was identified and transected at the level of the stylomastoid foramen. Its distal part was moved down to the neck after identification of the hypoglossal nerve. A 3–5 cm graft of sural nerve was harvested and interposed in the gap between the end of the distal part of the facial nerve and the lateral surface of the hypoglossal nerve. One end of the sural nerve was anastomosed by

Table 1 Details of the patients receiving hypoglossal–facial crossover

Patient	*Sex/Age (years)*	*Aetiology*	*House–Brackmann grade*	*Interval before surgery (months)*	*Nerve graft*	*Epineurium*	*Length of follow-up (months)*
Group I							
1	42/M	parotid tumour	—	none	yes	removed	12
2 (case 1)	45/F	acoustic neuroma	V	1	yes	removed	25
Group II							
3 (case 2)	32/F	acoustic neuroma	IV	9	no	intact	15
4 (case 3)	21/M	road traffic accident	IV	13	no	removed	16

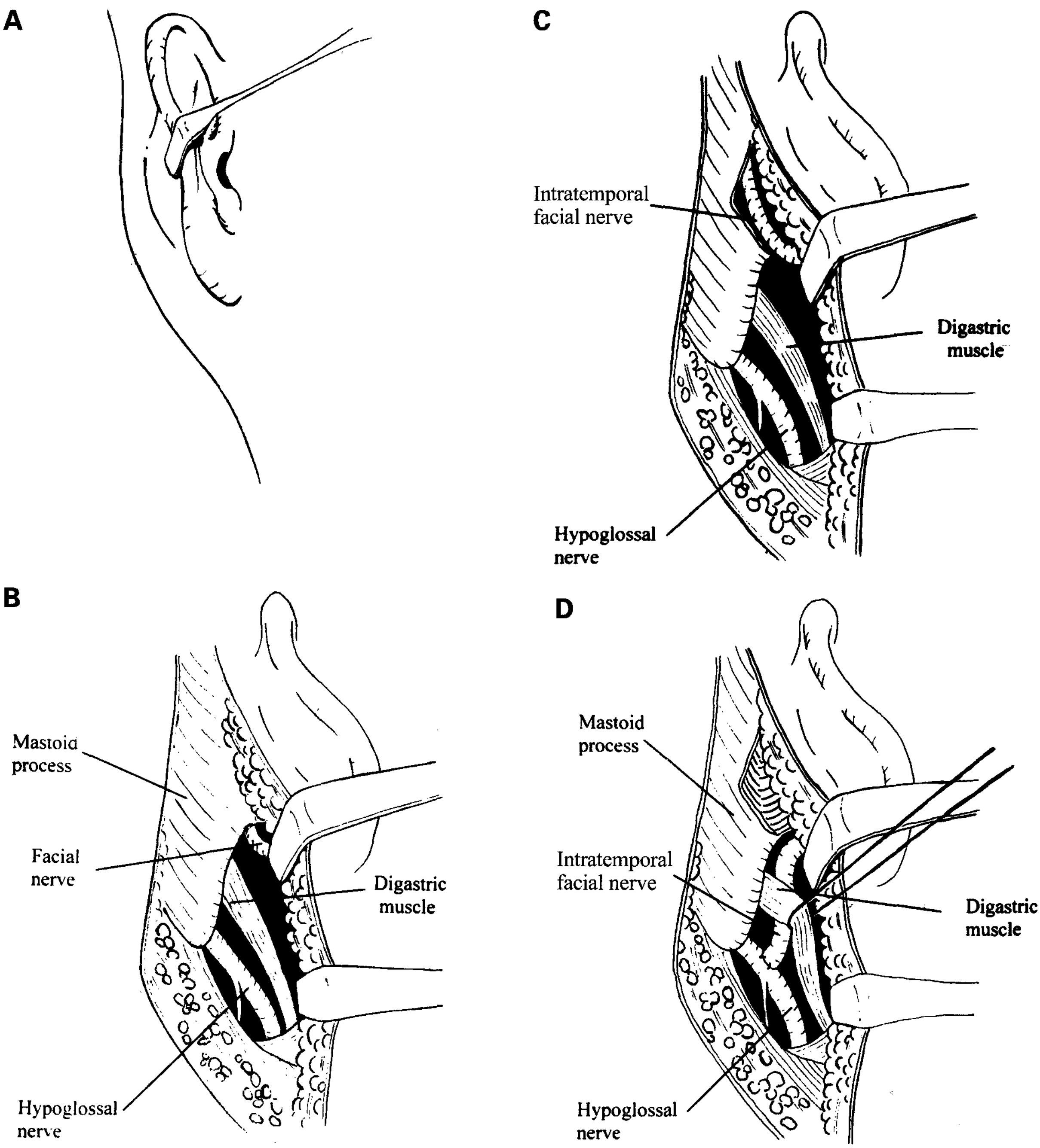

Figure 1—Surgical procedures involved in hypoglossal–facial crossover: (A) postauricular (or preauricular) incision; (B) identification of the facial nerve, the digastric muscle and the hypoglossal nerve; (C) preparation of the intratemporal facial nerve after mastoid ostectomy; and (D) mobilisation of the distal part of the intratemporal facial nerve followed by pure end-to-side anastomosis with the hypoglossal nerve.

end-to-end neurorrhaphy to the facial nerve, and the other end was connected to the hypoglossal nerve using pure end-to-side neurorrhaphy. During the end-to-side neurorrhaphy, the epineurium of the hypoglossal nerve at the anastomotic site remained intact.

Group II. A similar postauricular incision was extended 2–5 cm downward to the margin of the mandibular angle (Fig. 1A). The facial-nerve trunk was identified. The mastoid tip was removed, and the facial nerve in the temporal bone was skeletonised and mobilised out of the fallopian canal (Fig. 1B,C). The intratemporal facial-nerve trunk was transected at the level of the external genu of the facial nerve, and the cauda tympani nerve branch was sacrificed. The distal part of the facial nerve was moved out of the stylomastoid foramen, to the neck (Fig. 2A).

After identification of the digastric muscle and the hypoglossal nerve, the digastric muscle was retracted anteriorly using a sling, and the hypoglossal nerve was prepared by dissection of the adjacent tissue.

The distal part of the facial-nerve trunk was passed under the digastric muscle, and its end was approximated to the lateral surface of the hypoglossal nerve without tension. End-to-side neurorrhaphy was performed using four or five 9/0 nylon simple interrupted sutures (Figs 1D and 2B). The hypoglossal nerve was not incised, in order to preserve the nerve fascicles. The epineurium at the anastomotic site was removed in one patient but not in the other.

Case reports

Case 1

A 45-year-old female with an acoustic neuroma presented with hearing disturbance, dizziness and headache. She was treated by resection of the tumour. The facial nerve was transected during the operation, resulting in facial palsy. Facial deviation to the healthy side, blurring of the nasolabial fold and incomplete eye closure were seen (Fig. 3A,B). The House–Brackmann degree was grade V. After 1 week, a gold implant was inserted into the involved eyelid. Facial-nerve reconstruction was carried out 1 month after neurosurgery, and consisted of pure end-to-side anastomosis using an interpositional sural-nerve graft. Follow-up at 17 months revealed restoration of facial tone at rest and improvement of the facial deviation, but no evidence of facial expression (Fig. 3C,D).

Case 2

A 32-year-old woman underwent a partial resection of an acoustic neuroma, which resulted in facial-nerve palsy. The remnant tumour was removed 7 months after the first operation. Facial asymmetry appeared, with attenuation of the nasolabial fold and incomplete eye closure (Fig. 4A,B). Gold weighting was performed 2 weeks later. The House–Brackmann degree was grade IV. There was no evidence of other cranial-nerve palsy. The patient underwent hypoglossal–facial crossover a year after the neurosurgical operation. Intratemporal facial-nerve mobilisation and pure end-to-side anastomosis were performed as described above. The epineurium at the anastomosis

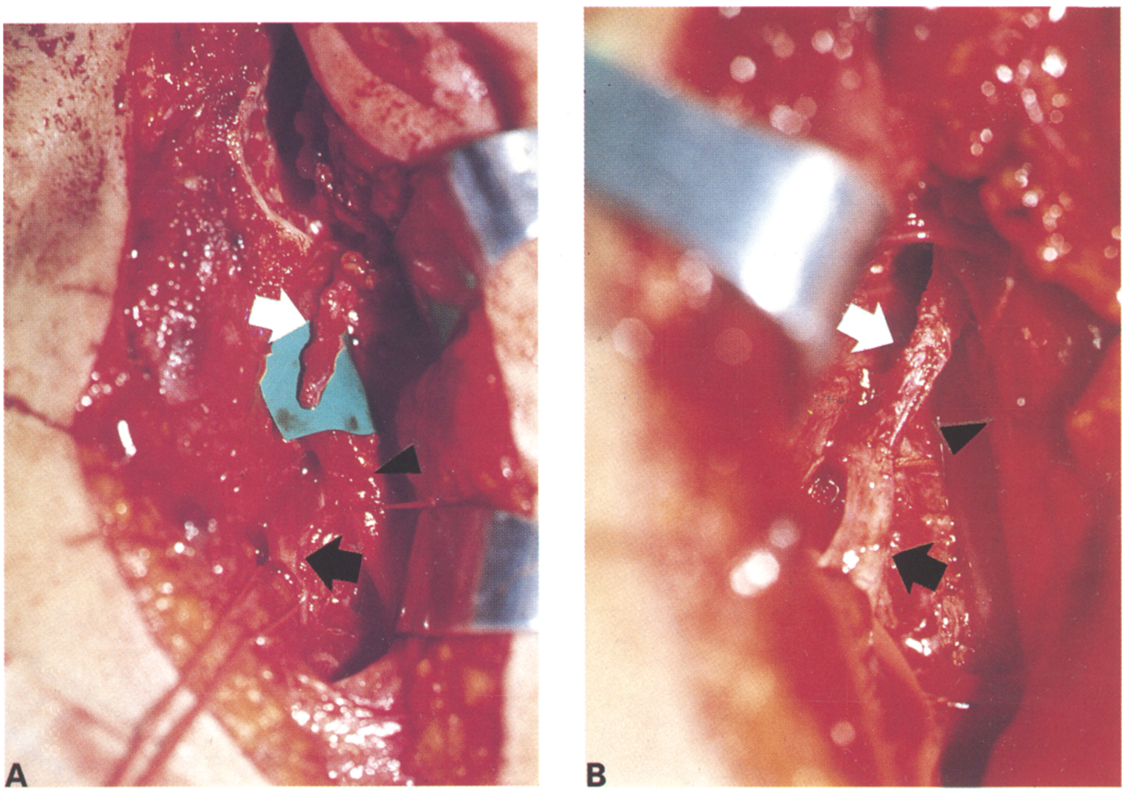

Figure 2—Intraoperative photographs. (A) The mastoid tip was removed and the facial-nerve trunk was transected at the level of the external genu. The distal part was mobilised and brought into the neck near the hypoglossal nerve. (B) Pure end-to-side anastomosis between the facial nerve and the hypoglossal nerve was performed. (White arrow: facial nerve; black arrow: hypoglossal nerve; black arrow head: digastric muscle.)

Figure 3—*Case 1.* A 45-year-old female after resection of an acoustic neuroma: (A) buccal deviation to the right and a blurred left nasolabial fold at rest, and (B) inability to pull out the left mouth corner. (C) The facial tone at rest was restored and facial deviation was improved 17 months after pure end-to-side anastomosis using a sural nerve graft. (D) However, there was no evidence of facial expression.

site was removed. Follow-up at 8 months revealed improved facial deviation at rest and a prominent nasolabial fold, together with the restoration of facial expression. There was noticeable eyelid ptosis due to the lid weighting (Fig. 4C–E).

Case 3

A 21-year-old man was involved in a road traffic accident, sustaining an epidural haematoma and a basal skull fracture, which was treated by craniotomy. This resulted in peripheral type facial palsy. The patient's eyelid closed incompletely, and forehead wrinkling was lost. Buccal deviation and a slight articulation disturbance were present (Fig. 5A,B). Fortunately, there was no sign of any other cranial-nerve palsy, such as auditory disturbance, deviation of the tongue, loss of the gag reflex or abnormal shoulder elevation. A CT scan showed low density in the right frontal and temporal lobes of the brain, and a skull-base fracture. An electromyogram of the facial nerve showed complete neuropathy. There was no spontaneous recovery of facial motion after 1 year, and so facial-nerve reconstruction was undertaken. Hypoglossal–facial crossover was performed, with the facial nerve being mobilised from the temporal bone and grafted to the hypoglossal nerve directly onto the epineurium. The donor nerve was not severed. Follow-up at 1 year revealed restoration of facial resting tone, a prominent nasolabial groove and correction of facial deviation. Facial expression had been restored and there was no evidence of hemiglossal atrophy (Fig. 5C–E).

Results

Follow-up took place at 2 monthly intervals, and the average follow-up time was 17.0 months. In group I, only facial tone was restored after 17 months, with no evidence of recovery of facial expression (Fig. 3).

In group II, resting facial tone was restored and subtle voluntary facial movements were seen after 8 months, which progressively improved. In case 2, subtle motion of the mouth corner and the nasolabial fold was possible.

Figure 4—*Case 2.* A 32-year-old female after resection of an acoustic neuroma: (A) facial deviation, blurring of the nasolabial fold, brow ptosis and loss of forehead wrinkles, and (B) aggravation of the facial deviation when attempting to pull out the mouth corner. (C) The facial deviation at rest was improved and the nasolabial fold was prominent 8 months after hypoglossal–facial crossover without a nerve graft. (D) After restoration of lid-closing ability, the eyelid looked ptotic because of the lid weighting. (E) Once facial reanimation had begun, the patient could pull out each mouth corner independently.

Facial deviation decreased and orbicularis oculi muscle group motion was restored. The eyelid closed completely (Fig. 4C): as the power of the oculi muscle recovered, the lid became ptotic because of the weight of the gold implant. There was no evidence of a gross change in the area of the frontal branch and the zygomatic branch.

In case 3, subtle movement of the infraorbital area began after 9 months. The levator labii group was slightly improved, and eye closure partially recovered after 12 months (Fig. 5C). He could elevate the corner of the mouth on the affected side, and this progressively improved. There was no change in his frontal or zygomatic territory.

None of the patients showed any evidence of hypoglossal functional deficit or hemiglossal atrophy (Fig. 5E).

Discussion

Hypoglossal–facial crossover has been refined since being reported by Körte in 1901. The classic end-to-end anastomosis is very effective in restoring facial function, but transection of the hypoglossal nerve results in hemiglossal atrophy and its sequelae.[4] Therefore, descendens hypoglossi, the branch of the hypoglossal nerve, has been used either to repair the hypoglossal nerve or for anastomosis to the facial nerve.[5] This leads to poor results due to inadequate axonal input.

In a further modification, the hypoglossal nerve was split using a longitudinal incision, in an attempt to adequately preserve its function.[5] However, the longitudinal incision also transected many axons, adversely affecting both the donor segment and the tongue supply.

Figure 5—*Case 3.* (A) A 21-year-old man presented with complete neuropathy of the right facial nerve at the skull base after an accident: (B) the right mouth corner was immobile. The facial tone at rest was restored 12 months after hypoglossal–facial crossover. (C) The nasolabial fold was prominent and the facial deviation was corrected. (D) During facial animation, he could pull out the right mouth corner laterally. (E) There was no evidence of hemiglossal atrophy.

May et al tried an interpositional jump graft to bridge the gap between the two nerves.[3] The hypoglossal nerve was incised distal to the descendens hypoglossi branch to avoid compromising the glottic innervation. Tongue function was preserved in 87% of patients. However, a weaker facial response and a longer recovery time of up to 2 years were observed, because of axonal loss and fibrosis resulting from multiple anastomoses during axon rerouting through the interposed nerve segment.

To solve the problems resulting from the use of an interpositional nerve graft, Hitselberger suggested mobilising the intratemporal facial nerve and bringing it down into the neck during anastomosis, making it possible to decrease the number of anastomoses without tension.[6] However, his method involved complete transection of the hypoglossal nerve.

More recently, Atlas and Lowinger introduced a technique of hypoglossal–facial crossover involving a smaller bevelled partial incision of the hypoglossal nerve and mobilisation of the intratemporal facial nerve.[1]

It is clear that incisions of any size on the hypoglossal nerve can damage it, with or without clinical manifestations. For this reason, multiple lower cranial nerve palsy, which is frequently combined with facial palsy after skull-base surgery, has been considered as a contraindication to hypoglossal–facial crossover.[1]

In 1992, Viterbo et al studied experimental lateroterminal neurorrhaphies in rats without removing the epineural sheath.[7] Since then, many studies using animal models have been published. The results show that nerve regeneration can occur after anastomosis without incising the donor nerve. Nerve regeneration is possible after end-to-side anastomosis, and regenerating fibres have the ability to penetrate the endoneurium, perineurium and epineurium.[8–10]

We attempted to restore the motor function of the facial nerve using a single direct end-to-side anastomosis without incising the hypoglossal nerve, by mobilising the intratemporal facial nerve for tension-free anastomosis without a nerve graft. We achieved facial reanimation within 9 months by rerouting the hypoglossal nerve to the facial nerve.

In group I, using a nerve graft, the results were poor. Only the resting tone was restored, with no improvement in facial expression, probably because of a loss of regenerating fibres and fibroses at the anastomotic sites at either end of the interpositional nerve graft. In group II, the functional recovery of the facial nerve progressively improved. The patients were able to move the affected mouth corner independently, but not enough to express their emotions in a smile. There was minimal recovery of the frontal and zygomatic territories, and an improvement in the eyelid closure.

There are two more benefits of this method. First, the anastomosis can be made anywhere on the donor nerve. When using an interpositional jump graft between the facial nerve and the incised hypoglossal nerve, the anastomotic site must be distal to the branch of desendens hypoglossi in order to decrease morbidity by saving more nerve fascicles to the tongue. Pure end-to-side anastomosis can be made anywhere on the donor nerve's epineurium if there is no tension. Second, there are no contraindications to performing this procedure. Even if there is multiple lower cranial nerve palsy, the hypoglossal–facial crossover can be performed without risk of synergic deterioration of pharyngeal function or articulation difficulties.[1]

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