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HEAD AND NECK

Reconstruction of complex defects of the extracranial facial nerve: technique of "the trifurcation approach"

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Abstract

Purpose Reconstruction of complex defects of facial nerve (FN) after extensive cancer surgery requires individualized solutions. We describe the trifurcation technique as a modification of the combined approach on example of two patients with locally advanced parotid cancer.

Methods Due to perineural invasion, extensive resection of the FN from the mastoid segment to the peripheral branches was required. For reanimation of the upper face, a complex cervical plexus graft was sutured end-to-end to the mastoid segment of the FN trunk. The branches of the graft enabled reanimation of three peripheral temporal and zygomatic branches. The mandibular branch was sutured end-to-side to the hypoglossal nerve (hypoglossal–facial nerve transfer, HFNT). Additionally, the buccal branch was independently reanimated with ansa cervicalis.

Results Facial reanimation was successful in both patients. Good resting tone and voluntary movement were achieved with a mild degree of synkinesis after 13 months. Patient 1 showed the Sunnybrook (SB) composite score 69 [76 (voluntary movement score) – 0 (resting symmetry score) – 7 (synkinesis score)]. In patient 2, the SB composite score was 76 (80 – 0 – 4, respectively).

Conclusions In this trifurcation approach, cervical cutaneous plexus provides a long complex nerve graft, which allows bridging the gap between proximal FN stump and several peripheral branches without great expenditure. In combination with the HFNT and ansa cervicalis transfer, this procedure enables the facial reanimation with low grade of synkinesis.

Keywords Complex facial nerve reconstruction · Parotid malignancy · Cervical plexus · Combined approach

Introduction

Use of the greater auricular nerve (GAN) as a graft for reconstruction of complex defects of the facial nerve (FN) is a widespread technique among head and neck surgeons [1–5]. The GAN graft is often used to bridge the gap between the proximal FN stump and the distal nerve branches in facial–facial reconstruction [2], or to bridge the gap between the proximal FN stump and the hypoglossal nerve to perform the hypoglossal–facial end-to-side nerve transfer (HFNT) [1, 3, 6]. Close anatomical proximity of the GAN and its diameter, matching the FN, are beneficial. Especially in reconstruction of FN defects after surgery for parotid cancer, GAN is already identified and dissected during surgery. This approach makes harvesting a sural nerve graft unnecessary. However, for reconstruction of more than one involved branch, the GAN graft might be insufficient [2]. For reconstruction of complex defects, Stennert [7] described the classic "combined approach" (Fig. 1b). Later on, this procedure was modified using the end-to-side HFNT instead of end-to-end [8]. The approach allows reconstruction of the FN with a big gap between the proximal nerve stump at the stylomastoid foramen or in the mastoid, and several loose peripheral facial branches (Fig. 1a). During this procedure, the gap between the proximal FN stump and the distal branches is reconstructed end-to-end using the

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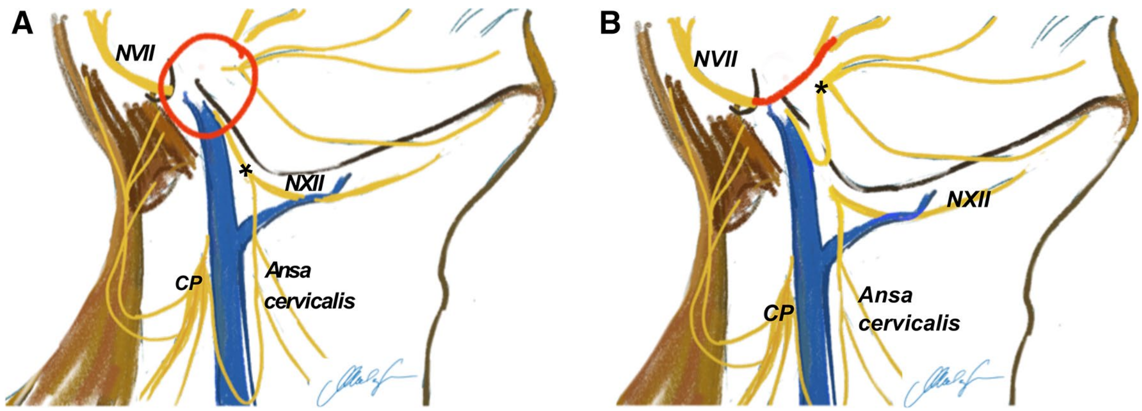

Fig. 1 Schematic presentation of complex defect of the facial nerve after resection of a parotid tumor (**a**). *CP* cervical plexus, *NXII* hypoglossal nerve, *NVII* facial nerve. **a** The defect of the peripheral facial nerve branches is marked by a red circle. **b** Schematic presentation of the classic combined approach, as described by Stennert, is shown. Here, (*) marks the end-to-end nerve transfer of the lower division of the facial nerve to the hypoglossal nerve. The cranial division of the facial nerve is reconstructed via an interponat (in red), which is sutured end-to-end to the mastoidal facial nerve stump

GAN graft (Fig. 1b). Then, the caudo-cervical division is reanimated via an end-to-end or end-to-side HFNT (Fig. 1b). This procedure has the potential additional advantage of less synkinesis, because the re-innervation of the upper face occurs independently of the lower face [6, 9].

We describe a reconstruction technique for complex defects of the peripheral FN after extensive surgery for parotid cancer, the trifurcation approach, using the cervical plexus, the hypoglossal nerve and the ansa cervicalis.

Methods

The approach is described by example in two patients who were treated for parotid cancer in the Department of Otorhinolaryngology, Head and Neck Surgery of the University Hospital of Cologne, Germany. Both patients have given a written permission for publishing.

Case 1 A 47-year-old male patient presented with an asymptomatic tumor in the left parotid gland. No facial palsy was present. Sonography revealed a round parotid lesion with clear margins. No malignant cells were present in the preoperative fine needle aspiration cytology. The patient was scheduled for a superficial parotidectomy. During surgery, the tumor clinically infiltrated the trunk and the bifurcation of the FN. Intraoperative frozen sections of the tumor tissue revealed the invasive adenocarcinoma of the parotid gland.

Case 2 A 42-year-old female patient was referred from another hospital with a histologically verified adenoid-cystic carcinoma of the right parotid gland. The diagnosis of parotid cancer was confirmed after superficial parotidectomy was carried out. At admission, the patient presented with an incomplete FN palsy (House–Brackmann score (HB) IV). Infiltration of the facial nerve at the stylomastoid foramen was suspected on the MRI.

Facial reanimation technique

Radical parotidectomy, mastoidectomy and neck dissection were carried out. The trunk of the FN and the peripheral nerve branches beyond the bifurcation had to be resected because of perineural invasion (Figs. 2, 3). Mastoidectomy was performed to ensure R0 resection and to gain a non-infiltrated proximal segment of the FN (Fig. 3). During the neck dissection, healthy GAN was dissected in a retrograde manner to the Erb's point and further to the origin of the cervical plexus. A long nerve graft, which included the GAN and the transversal cervical nerve, was harvested (Fig. 2). We used this complex branched graft to reconstruct the upper face. The mastoid segment of the FN was sutured end-to-end to the trunk of the graft (Figs. 2, 3). The peripheral braches of the graft were sutured end-to-end to four facial temporal and zygomatic branches (Figs. 2, 3). An end-to-side HFNT was carried out to reanimate the lower face (Figs. 2, 3). The marginal mandibulae branch was sutured end-to-side to the hypoglossal nerve. Additionally, ansa cervicalis was sutured end-to-end to the buccal branch (Figs. 2, 3). All sutures were carried out using non-resorbable sutures (10-0 Ethilon, Ethicon). The entire surgical procedure, which includes radical parotidectomy, mastoidectomy, neck dissection and facial nerve reconstruction, took about 5–6 h. An upper lid gold weight (1.2 g) was implanted in both patients to secure the closure of the eye.

After final histopathological and radiological staging, the parotid cancer was characterized as pT4pN2bcM0 invasive adenocarcinoma NOS in Case 1 and pT4pN0cM0

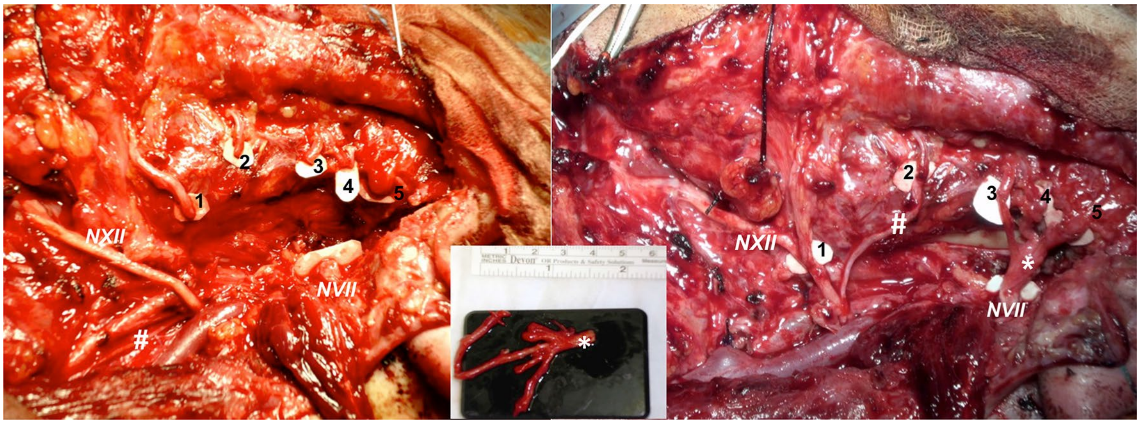

Fig. 2 Perioperative situs before and after the facial reanimation in Case 1. (*) Marks the harvested cervical plexus graft and the graft after the suture to the zygomatic and the temporal branches (numbers 3, 4, 5); (#) marks the ansa cervicalis before and after transposition and suture to the buccal branch (number 2). Marginal branch (number 1) is sutures end-to-side directly to the hypoglossal nerve (NXII). *NVII* = facial nerve stump; 1 = marginal branch, 2 = buccal branch, 3, 4 and 5 = zygomatic and temporal branches

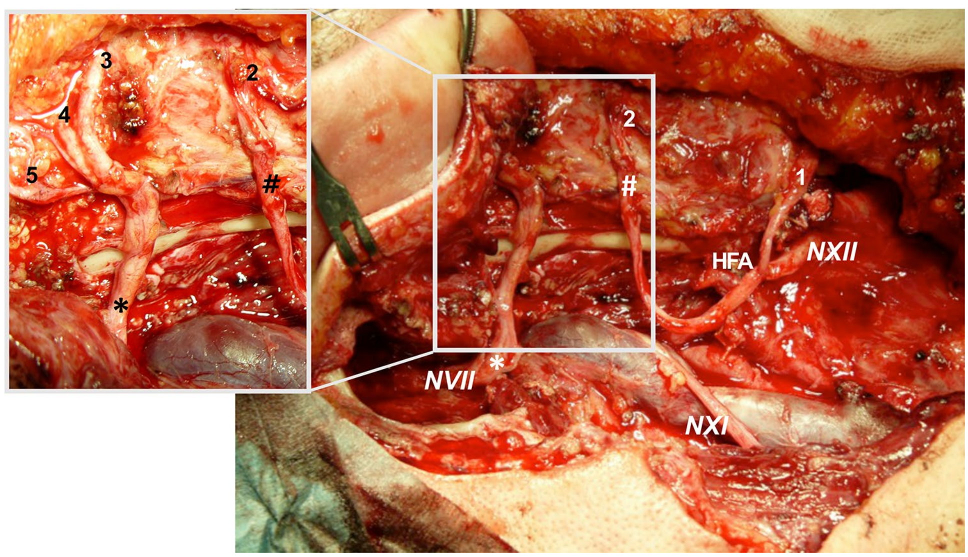

Fig. 3 Perioperative situs of the trifurcation approach in Case 2. (*) Marks the cervical plexus graft, which is sutured end-to-end to the mastoid segment of the facial nerve (NVII). HFA points to the end-to-side hypoglossal–facial anastomosis with the marginal mandibular branch. (#) Points to the end-to-end suture of the buccal branch to the ansa cervicalis. *NXII* hypoglossal nerve

adenoid-cystic carcinoma in Case 2. Both patients underwent adjuvant radiotherapy.

Results

Follow-up of facial function and needle-electromyography (EMG) took place every 3 months. In the EMG, the re-innervation in the frontal, orbicularis oculi, nasalis and depressor anguli oris muscles was monitored at each visit. The function of the tongue was normal in both patients. First re-innervation potentials were present after 6 months in the depressor anguli oris and the nasalis muscles. The voluntary activity could be intensified by the movement of the tongue. From then, physiotherapy was additionally recommended. After 9 months, electromyographic re-innervation potentials were furthermore evident in the orbicularis oculi and the frontalis muscles. The resting state of the face and the tonus of the mimic musculature were good (Sunnybrook (SB) Resting Symmetry Score 10 in Case 1 and Score 5 in Case 2). However, both patients showed an asymmetry of the depressor anguli oris muscle during smiling and snarling.

After 13 months, patient 1 showed synkinetic movements between the upper and the lower face division (mentalis muscle, platysma) (Fig. 4a). According to the SB Grading System, the composite score was 69 (resting symmetry 0, voluntary movement 76, synkinesis 7). In patient 2, the SB composite score was 76. However, synkinesis was still present between the forehead and the midface (Synkinesis score

Fig. 4 Facial nerve function with discrete synkinesis in Case 1 (**a**) and Case 2 (**b**) after 13 months

4) (Fig. 4b, Suppl. Video 1). We treated the synkinesis and hyperkinesis of the orbicularis oculi muscle with botulinum toxin in Case 1, and the synkinesis of the forehead and the midface (levator labii superioris muscle) in Case 2.

Discussion

Numerous techniques for facial reanimation are described [2, 3, 9, 10]. In parotid cancer, the extent of tissue invasion and perineural infiltration often cannot be precisely predicted preoperatively [4]. In our first case, the male patient showed no preoperative FN palsy. The EMG might indicate perineural spread in selected cases [4, 11]. However, EMG is not widely available. Furthermore, if nerve infiltration is discovered during surgery, the nerve tissue has to be resected to ensure clear resection margins, even if no spontaneous activity was evident in the preoperative EMG [4, 11, 12]. If parotid cancer is suspected, MRI is the recommended method of choice to overview the dimensions of the tumor and its infiltration pattern before surgery [4, 12, 13]. However, the diagnosis of malignant lesions of the parotid gland is often raised by incident [13]. More frequent application of fine needle aspiration cytology in patients with a parotid mass might enable more accurate planning of surgery and information of patients [12, 13]. However, even if the preoperative diagnostics indicate malignancy, the precise extent of final facial reconstruction is only evident during surgery [4].

In our case series, numerous peripheral branches required reanimation. The proximal segment of the FN has to be rerouted to the mastoid to ensure the R0 resection and to enable nerve suture. The most common reconstruction technique in this case uses various interposition grafts, which are sutured end-to-end altogether to the FN main trunk [1, 2]. Because of the requirement for variously long donor nerve grafts, the dissection of the sural nerve is often needed [2]. This technique is likely to result in more synkinetic defective healing though [6, 7, 9]. Use of the combined approach [9] significantly decreases synkinesis. However, if the reconstruction of the upper face requires the interposition of the facial trunk to numerous peripheral branches, use of the GAN is limited by its length and diameter.

The cutaneous cervical nerve plexus originates from the anterior branches of the first four cervical spinal nerves C1 to C4 and includes the lesser occipital, the GAN and transversal cervical and supraclavicular nerves [14]. The cervical plexus provides tactile sensation to the occipital, periauricular, parotid and anterior lateral cervical and supraclavicular areas of the head and neck. It can be easily identified during neck dissection. Dissection of the entire cervical plexus enables the harvest of a long (~ 10 cm), thick and branched graft able to reanimate complex nerve defects. During surgery for parotid cancer, neck dissection is often performed during the same operation. Therefore, dissection of the plexus is not associated with additional morbidity and does not consume additional surgery time. However, sacrifice of the branches of the cervical plexus leads to reduced tactile sensation of the supply area [14]. Nevertheless, even in revision parotidectomy without available GAN, transversal cervical and supraclavicular nerves are still available for reconstruction.

The use of ansa cervicalis as donor nerve in facial reanimation was previously described elsewhere [15]. However, its use is still uncommon in facial reconstruction because of unreliable results. Ansa cervicalis is most often used to obtain musculature tonus in denervated vocal cord [16]. Therefore, we reanimated the buccal branch with ansa to gain additional musculature tonus in the midface. The use of the masseteric nerve might be considered as an alternative procedure [4].

We performed a direct end-to-side HFNT for reanimation of the marginal mandibular branch. Previous clinical and histological studies have shown an advantage of the hypoglossal nerve as a donor for reanimation of the lower face [1, 3, 5]. Because of neuronal communication between the brain stem nuclei of the hypoglossal and the FN, the so-called synaptic cross talk enables future voluntary movement of the lower face without voluntary involvement of the tongue [10]. This mechanism is crucial for the recovery of the "spontaneous smile", which has a great impact on patients' quality of life. Despite the deficit in the depressor anguli oris muscle, the elevation of the angle of the mouth could be obtained in both cases. We do not recommend sacrifice of the entire hypoglossal nerve because of very high morbidity of the tongue atrophy. Various previous publications have confirmed that regular tongue function remained after an end-to-side suture [1, 9].

Synkinetic re-innervation cannot be completely avoided using any reanimation technique. We observed mild synkinesis defective healing in our patients, which contradicts original reports about the combined approach [7, 8]. Human electrophysiological and anatomical studies described highly variable anastomotic patterns of peripheral facial branches [17], which provide highly variable innervation of facial muscles [18]. Furthermore, Bendella et al. [17] emphazised the crucial role of the buccal branch favoring synkinesis between the upper-, the mid- and the lower face. In our cases, we still observed synkinetic re-innervation despite independent reanimation of the buccal branch. However, additional buccal branch re-innervation might affect the degree of synkinetic movement and should be assessed in a larger series of patients.

In this trifurcation approach, the cervical cutaneous plexus provided a long and stable complex nerve graft, which allowed bridging of the gap between proximal FN stump and several peripheral branches without great expenditure. In combination with an end-to-side HFNT, and with an additional reanimation of the buccal branch with ansa cervicalis, this approach enables the facial reanimation with low grade of synkinesis.

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Compliance with ethical standards

Conflict of interest Both authors declare that they have no conflict of interest.

Ethical approval All procedures performed in this study involving human participants were in accordance with the ethical standards of the national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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