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CT-Based Intraoperative Navigation for Quick Identification of the Stylomastoid Foramen During Hypoglossal-Facial Nerve Anastomosis

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ABSTRACT

AIM: To present the ability of standard intraoperative neuronavigation to reliably identify the stylomastoid foramen, thus providing a quick and effective recognition of the facial nerve at its exit from the skull base.

MATERIAL and METHODS: We describe the technical nuances of this procedure by presenting two surgical cases who underwent hypoglossal-facial nerve anastomosis for complete facial nerve palsy occurring post removal of a giant vestibular schwannoma 6 months earlier.

RESULTS: CT-based neuronavigation allowed a quick and reliable identification of the stylomastoid foramen and of the facial nerve at its exit from the skull. The entire procedure lasted for 3 hours. Three months after the anastomosis, the first signs of facial muscle reinnervation were visible.

CONCLUSION: The use of neuronavigation during hypoglossal-facial nerve anastomosis is a simple and cost-effective strategy to decrease operative duration and increase surgical effectiveness.

KEYWORDS: Hypoglossal-facial nerve anastomosis, Stylomastoid foramen, Facial nerve palsy, Navigation

ABBREVIATIONS: CT: Computed tomography, **EMG:** Electromyography, **FN:** Facial nerve, **HFA:** Hypoglossal-facial nerve anastomosis, **HN:** Hypoglossal nerve, **IRB:** Institutional Review Board, **SMF:** Stylomastoid Foramen

INTRODUCTION

Hypoglossal facial nerve anastomosis (HFA) is the reconstructive technique of choice when invalidating facial nerve (FN) palsy occurring after a trauma or vestibular schwannoma/skull base surgery. The hypoglossal nerve (HN) is easy to find during dissection at the submandibular triangle, and its identification is confirmed by direct electrical stimulation. On the contrary, FN at the emergence of the stylomastoid foramen (SMF) is not easy to recognize, though several landmarks have been suggested (18,19). One of the reasons for such difficult FN identification is the appearance of the degenerated nerve: a few months following the trauma, the FN loses its normal look and texture and can be confused with neighbouring vascular or fibrous structures (2,6). Among other reasons, the richness of vascular and nervous structures in that small area of the skull base and a certain inter-individual anatomical variability must be taken into account. Next, we

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propose a computed tomography (CT)-based intraoperative neuronavigation tool, allowing us to identify the SMF with a mean error of 1–2 mm. Here we describe a surgical case of end-to-end HFA, wherein the identification of FN emergence at SMF was facilitated and the procedure was accelerated by neuronavigation.

MATERIAL and METHODS

Ethical approval was waived by the local Ethics Committee in view of the retrospective nature of the study and since all the procedures being performed were part of the routine care. Patients' consents were obtained.

Case 1

A 34-year-old man approached our institution for gross-total excision of a large left vestibular schwannoma (Koos grade IV), via a retrosigmoid approach, in June 2020 (Figure 1A, B). Anatomically, the nerve seemed to be uninterrupted from the brainstem to the internal auditory meatus; however, post-operatively, a severe FN palsy (House-Brackmann V) was clinically evident. A close ophthalmologic follow-up was prescribed, which prevented corneal damage. The patient underwent facial rehabilitation without benefit. Six months after the surgery, electromyography (EMG) confirmed complete left FN palsy with partial reinnervation of frontal and orbicularis oculi muscles from the contralateral side. Therefore, in January 2021, HFA surgery was warranted for this case.

Case 2

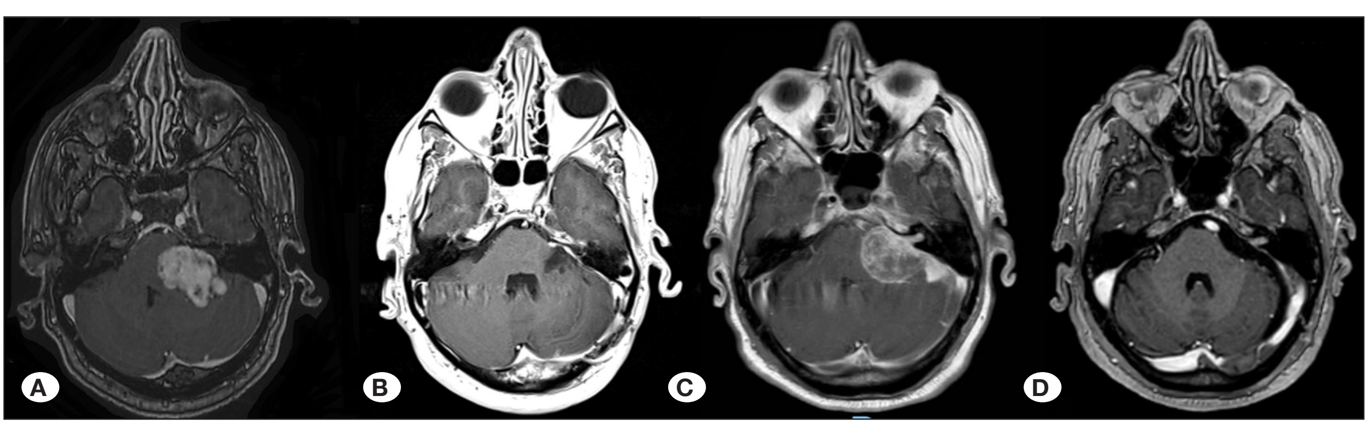
A 75-year-old man approached us for a complete surgical removal of a left vestibular schwannoma with a retrosigmoid approach in March 2021 (Figure 1C, D). Intraoperatively, the FN was completely dislocated by the mass, but at the end of procedure, the nerve appeared intact. A House-Brackman IV nerve palsy was observed during the postoperative period. A left tarsorrhaphy was performed, avoiding a corneal damage. Facial rehabilitation proved to be unsuccessful. After 4 months, the EMG confirmed a complete left FN palsy. Hence, in July 2021, HFA was performed.

RESULTS

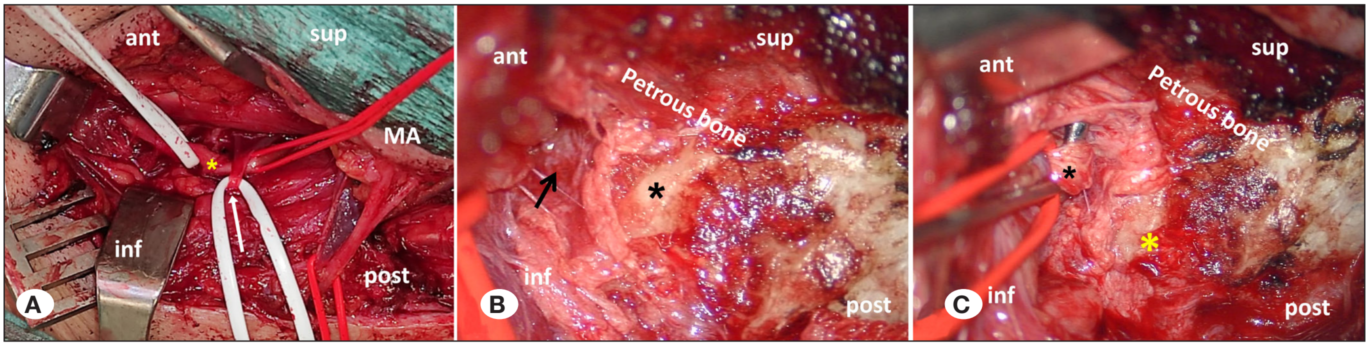
On the operating table, the patient was put in a supine position with the head slightly extended and contralaterally rotated (90°). A 3D CT scan obtained before surgery was loaded onto the electromagnetic surgical navigation system (StealthStation®, Medtronic, Minneapolis, MN) with the following parameters for 3D CT acquisition: slice thickness 1.25 mm, gantry tilt 0°. The magnetic tracer was used with accuracy of under 1.5 mm of error, for a reliable reconstruction of head profile and SMF. A skin incision from the mastoid tip to the submandibular chin line was performed (5). Under the operating microscope, HN could be easily found at the level of the mandibular angle when it passed medially to the posterior belly of the digastric muscle, crossed by the occipital artery (Figure 2A). Subperiosteal dissection was then performed to partially separate the insertion of the sternocleidomastoid muscle, for exposing the mastoid tip. Localization of the mastoid tip was confirmed by navigation, with an error of less than 2 mm. Careful drilling of the mastoid tip allowed access to the region of the SMF (Figure 2B). At this point, precise localization of the styloid process and SMF was greatly accelerated using neuronavigation (Figure 3). The FN was therefore identified (Figure 2C) and cut at its most proximal exit point from the skull. HN was cut immediately before the origin of its distal branches and moved towards the distal FN stump. An end-to-end HFA was then performed with a 10-0 nylon suture and fibrin glue (Figure 4). The whole procedure, from the skin incision to the last stitch, lasted for a mean duration of 3 hours, apart from 15 minutes for navigation set-up. Following 3 months from the operation, in case of both patients who underwent facial muscles rehabilitation, facial muscles tone was seen to increase and neurophysiological examinations showed the first signs of regeneration of axons.

DISCUSSION

In this paper, we have aimed to suggest that intraoperative neuronavigation is a promptly available and effective strategy to rapidly identify a degenerated FN at the SMF during the HFA procedure. The use of neuronavigation is presently a part



Figures 1: A, C) Preoperative magnetic resonance imaging (MRI) with iv gadolinium shows the mass effect of the tumour in the left cerebellopontine angle on brainstem and VII and VIII cranial nerves for Cases 1 and 2, respectively. **B, D)** Postoperative MRI with iv gadolinium shows complete removal of schwannoma with hypointensity of surrounding tissue for Cases 1 and 2, respectively.



Figures 2: A) Identification of the left hypoglossal nerve (HN; asterisk) at the submandibular triangle, the occipital artery (arrow) and the mandibular angle (MA). **B)** Identification of mastoid tip (asterisk) and dissection of the stylomastoid foramen (SMF) region (arrow). **C)** Identification of the degenerated left facial nerve (**FN;** black asterisk) and of mastoid tip (yellow asterisk).

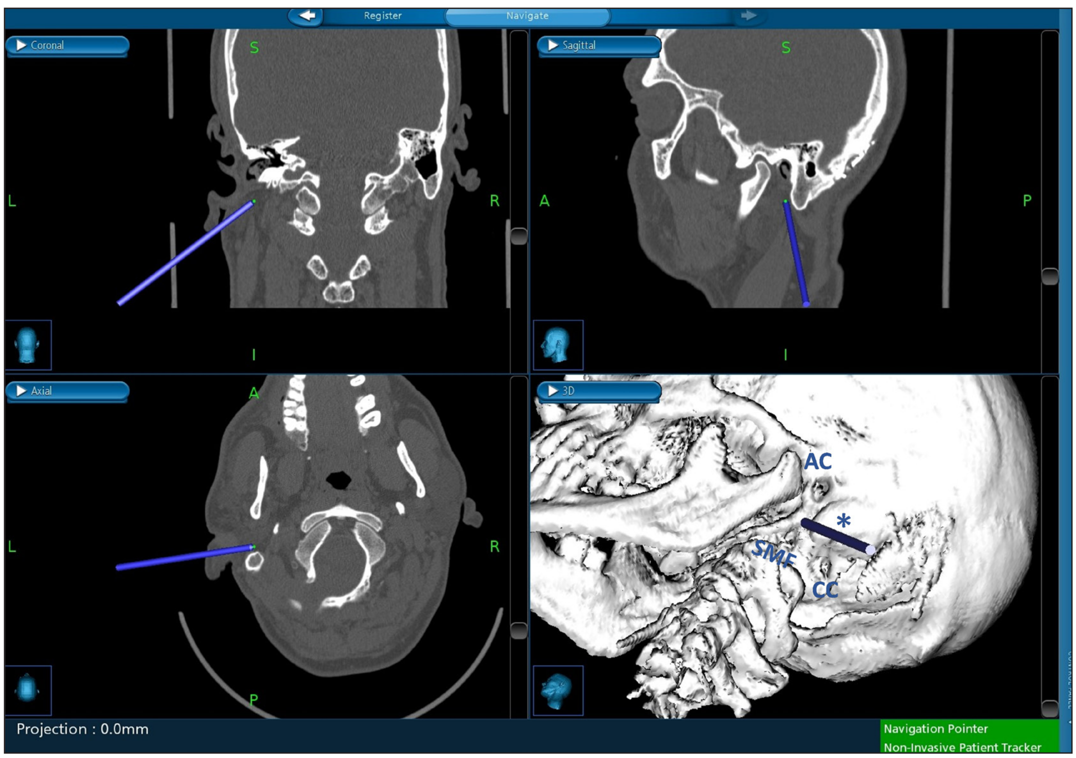


Figure 3: Precise identification of the stylomastoid foramen (SMF) with magnetic computed tomography (CT)-based neuronavigation (StealthStation, Medtronic); acoustic canal (AC), condyloid canal (CC) and mastoid tip (asterisk) are also recognizable.

of the routine practice in several neurosurgical procedures, particularly at academic centres. HFA is a widely used technique to reanimate the FN after its complete loss of function due to multiple causes, such as trauma or surgery. Several strategies for HFA anastomosis have been proposed, whose comparison is beyond the scope of this paper (1–3,9–11,13,14,16,17). Side-to-end hypoglossal-facial anastomosis is currently considered the standard-of-care technique, because of its good rate of success in facial reanimation and in the preservation of hemitongue function (3,10,16).

There exist several variants of the procedure, most of them requiring mobilization of the mastoid/temporal segment of the FN: this is a delicate and time-consuming surgical step that would benefit in terms of accuracy and speed through bone neuronavigation, as seen in the cases we have described above. Moreover, a recent literature review showed that the alternative technique of longitudinal HN splitting may cause trauma to the axonal bundles, which could in turn lead to unsatisfactory results post anastomosis (11). That said, in selected cases of patients whose lower cranial nerves' function is unremarkable, we prefer to perform end-to-end HFA that guarantees a shorter duration for regenerating axons. On the basis of such careful selection of patients, our experience showed that hemitongue palsy is generally well-tolerated, as seen in the cases presented above. However, apart from the technique used, the identification of the FN at the SMF is the most crucial and hazardous part of the operation. Incorrect recognition of the nerve results in a failure of the entire procedure.

Various landmarks have been suggested in the existing

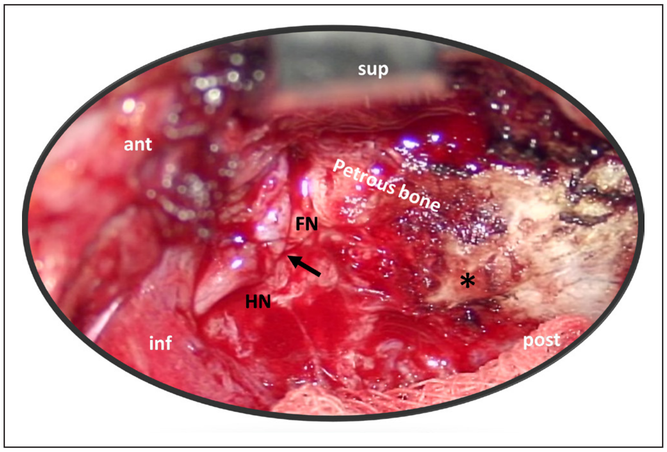


Figure 4: Microanastomosis between the distal stump of the left facial nerve (FN) and the proximal stump of the left hypoglossal nerve. The arrow marks the site of anastomosis between FN and hypoglossal nerve (HN). The asterisk marks the mastoid tip.

literature for localizing the FN, but none of these is impeccable (1–4,7,15,17–19). Campero et al. described a very detailed method to identify the FN through different HFA techniques (2). The pre-bifurcation extracranial FN was evaluated with regard to the external auditory meatus, the mastoid and the styloid processes, the atlas, the mandibular condyle and the digastric muscle, using a preauricular approach. However, the position of these landmarks has an interpatient variability, in the range of millimetres, making their use only partially reliable, overall. Also the styloid process palpation might baffle the surgeon during the procedure, since its shape and number may differ from patient to patient and from side to side (8,12). Tayebi Meybodi et al. tried to analyze qualitative and quantitative landmarks to easily identify the FN at the emergence of SMF (18), suggesting the use of the digastric branch of the FN as the most reliable one. However, this is a tiny branch that could be injured during dissection.

In the cases under study, the precise identification of all these landmarks, particularly the base of the styloid process, was enormously facilitated using a simple CT-based neuronavigation system during surgery. Using such a system, we had a total surgical time of 180 minutes on an average, compared to a mean surgical time of 300 minutes needed in previous HFA surgeries performed at our institution without the use of neuronavigation. Though some authors reported the use of an intraoperative CT based-neuronavigation for confirmation of foramen ovale during cannulation for Trigeminal Rhizotomy, this is the first report, to the best of our knowledge, about the use of neuronavigation to perform HFA (20).

CONCLUSION

Anatomical knowledge of the key landmarks is fundamental prerequisite for safe performance of HFA surgery. In the present paper, however, we have suggested a simple strategy aimed at accelerating the success rate of HFA based on neuronavigation guidance.

AUTHORSHIP CONTRIBUTION

Study conception and design: AMA

Data collection: QGD, PPM, EMFM

Analysis and interpretation of results: QGD

Draft manuscript preparation: QGD, AMA

Critical revision of the article: QGD

Other (study supervision, fundings, materials, etc...): AMA, QGD, PPM, LL

All authors (AMA, QGD, PPM, EMFM, LL) reviewed the results and approved the final version of the manuscript.

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