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Surgical anatomy of the facial nerve: from middle cranial fossa approach to endoscopic approach. A pictorial review

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Abstract

Purpose The pathology of the facial nerve is extremely varied and extensive knowledge of the surgical anatomy in different approaches is required to manage it. During the last 15 years, the development of endoscopic ear surgery has significantly changed anatomical concepts, introducing new surgical approaches. The aim of this review is to illustrate five different surgical approaches to the facial nerve: the endoscopic approach, the middle cranial fossa approach, two translabyrinthine approaches (one simple and one endoscopic-assisted) with decompression of the whole petrous portion of the facial nerve, and a transotic approach with temporal craniotomy.

Methods Representative cases of middle and/or inner ear pathologies, surgically treated at our ENT Department, were selected to illustrate each of the five different approaches involving the facial nerve throughout its course.

Results In all cases, the pathology was removed with effective decompression of the facial nerve. The surgical anatomy in each surgical approach is described and illustrated.

Conclusions Facial nerve surgery is challenging for ENT specialists. An excellent knowledge of facial nerve anatomy is needed to eradicate pathology, avoiding nerve injuries and providing a good outcome after surgery.

Keywords Facial nerve anatomy · Middle cranial fossa · Translabyrinthine · Transmastoid · Endoscopic decompression

Introduction

The facial nerve (FN) is the seventh paired cranial nerve. It is a mixed nerve with sensory, parasympathetic and motor branches. The anatomy of the FN is complex and pathologies that can involve it are extremely varied.

Dealing with conditions treatable with surgery, lesions can originate from the nerve or can extend to involve it. From a histological point of view, benign neoplasms (including schwannomas and paragangliomas), malignant neoplasms (for example, perineural spread of tumors or lymphomas), cholesteatoma, vascular lesions (including hemangiomas and aneurisms of the anterior inferior cerebellar artery, AICA), traumatic injuries and meningoceles of the fallopian canal have been described [1–4].

A careful analysis of symptoms and a preoperative study with Computed Tomography (CT) scan and Magnetic resonance imaging (MRI) are crucial to make a diagnosis and to plan the best surgical approach. Different surgical approaches are possible, with specific indications, contraindications and results, and the choice of surgery is made based on the portion of the nerve involved, the type and extent of the pathology, the possibility of hearing preservation, and encasement of the internal carotid artery. In the literature, classical surgical approaches for pathologies involving the FN are the transmastoid approaches, the middle cranial fossa (MCF) approach and the translabyrinthine approach [5]. However, during the last 15 years, the development of endoscopic ear surgery has significantly changed anatomical concepts, introducing new surgical approaches [6–8].

The aim of this review is to describe the different approaches to the FN using five representative cases.

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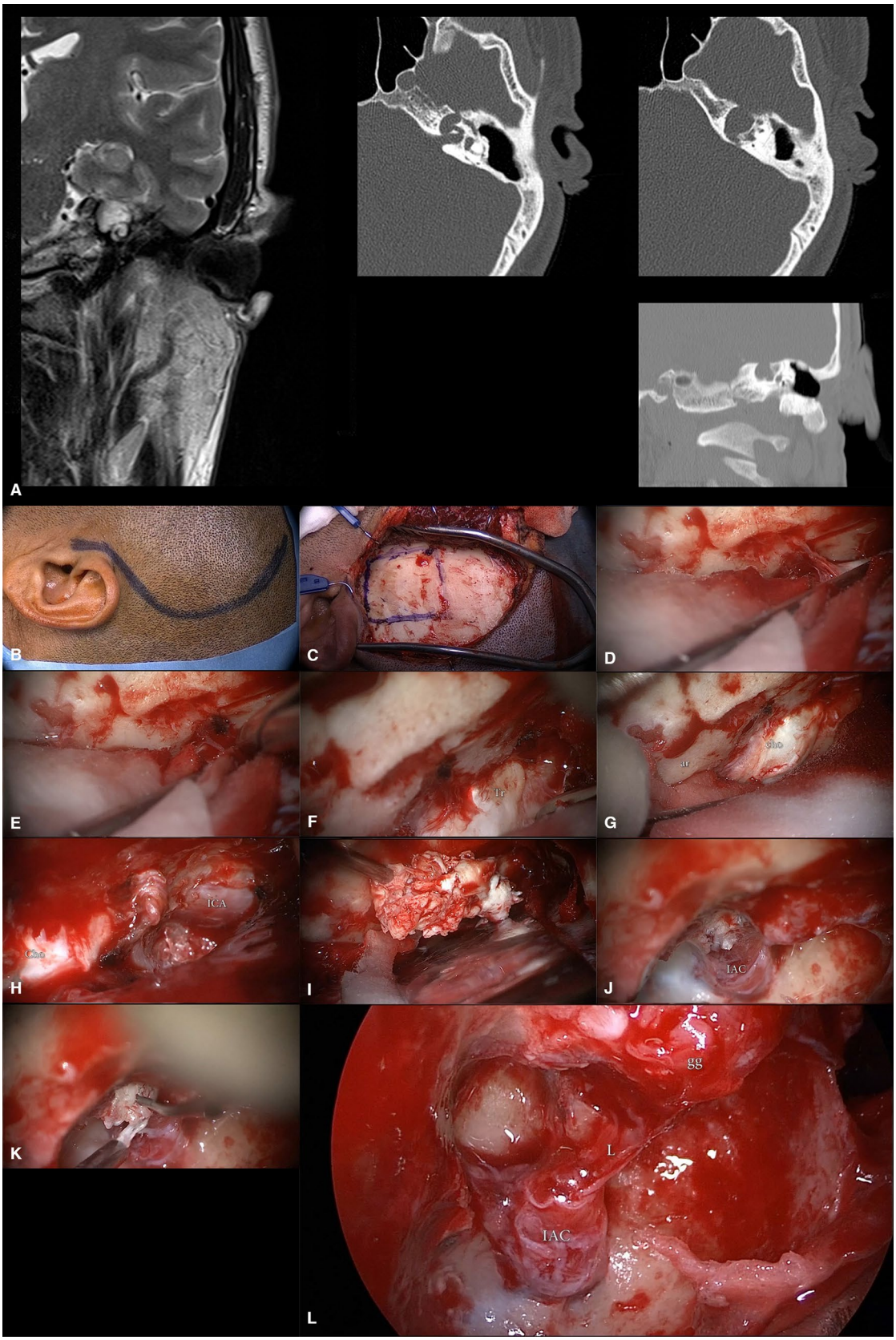
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◂**Fig. 1** Middle cranial fossa approach. Left ear. **a** Preoperative CT scan (upper left and lower left) and MRI (right) showing the cholesteatoma involving the floor of the middle cranial fossa as far as the internal auditory canal (IAC). **b** Incision in the shape of a question mark; **c** quadrangular craniotomy; **d** middle meningeal artery; **e** great petrosal nerve (the middle meningeal artery appears coagulated and transected superiorly); **f** *Tr* trigeminal nerve; **g** *ar* arcuate eminence, *cho* cholesteatoma; **h** *ICA* internal carotid artery, *cho* cholesteatoma; **i** removal of the first portion of cholesteatoma; **j** the residual cholesteatoma involving the internal auditory canal (IAC); **k** removal of the pathology; **l** endoscopic check of the surgical field. *L* labyrinthine segment, *IAC* internal auditory canal, *gg* geniculate ganglion

Materials and methods

Pictorial review of patients affected by middle and/or inner ear pathologies, spreading or involving the facial nerve, surgically treated at our ENT Department. Patient characteristics, type of lesion and surgical steps are described, focusing on the surgical anatomy of the facial nerve. Informed consent was obtained from all individual patient involved in this article.

Results

Five representative cases were analyzed and described: one MCF approach, one endoscopic-assisted transmastoid translabyrinthine approach, one simple transmastoid translabyrinthine decompression of the whole petrous portion of the facial nerve, one transotic approach with temporal craniotomy, and one totally endoscopic approach, all treated at our tertiary referral center.

Middle cranial fossa approach

Rationale

The MCF approach is a well-estabilished route to reach the labyrinthine and upper tympanic segments of the FN, allowing hearing preservation.

Case presentation

A 39-year-old man with a history of bilateral chronic otitis media with cholesteatoma, affected by a recurrence of cholesteatoma involving the medial wall of the petrous pyramid and the facial nerve at the level of the geniculate ganglion and the labyrinthine portion as far as the fundus of the internal auditory canal (IAC) on the left side. The preoperative CT scan and MRI are shown in Fig. 1. The patient had a preoperative facial nerve palsy (grade IV according to the House–Brackmann classification). The preoperative audiogram showed a bilateral mixed hearing loss. The Pure Tone Average of the 500–1000–2000–4000 Hz was: air conduction (AC) 55 dB, bone conduction (BC) 30 dB on the right side; AC 82 dB and BC 54 dB on the left side.

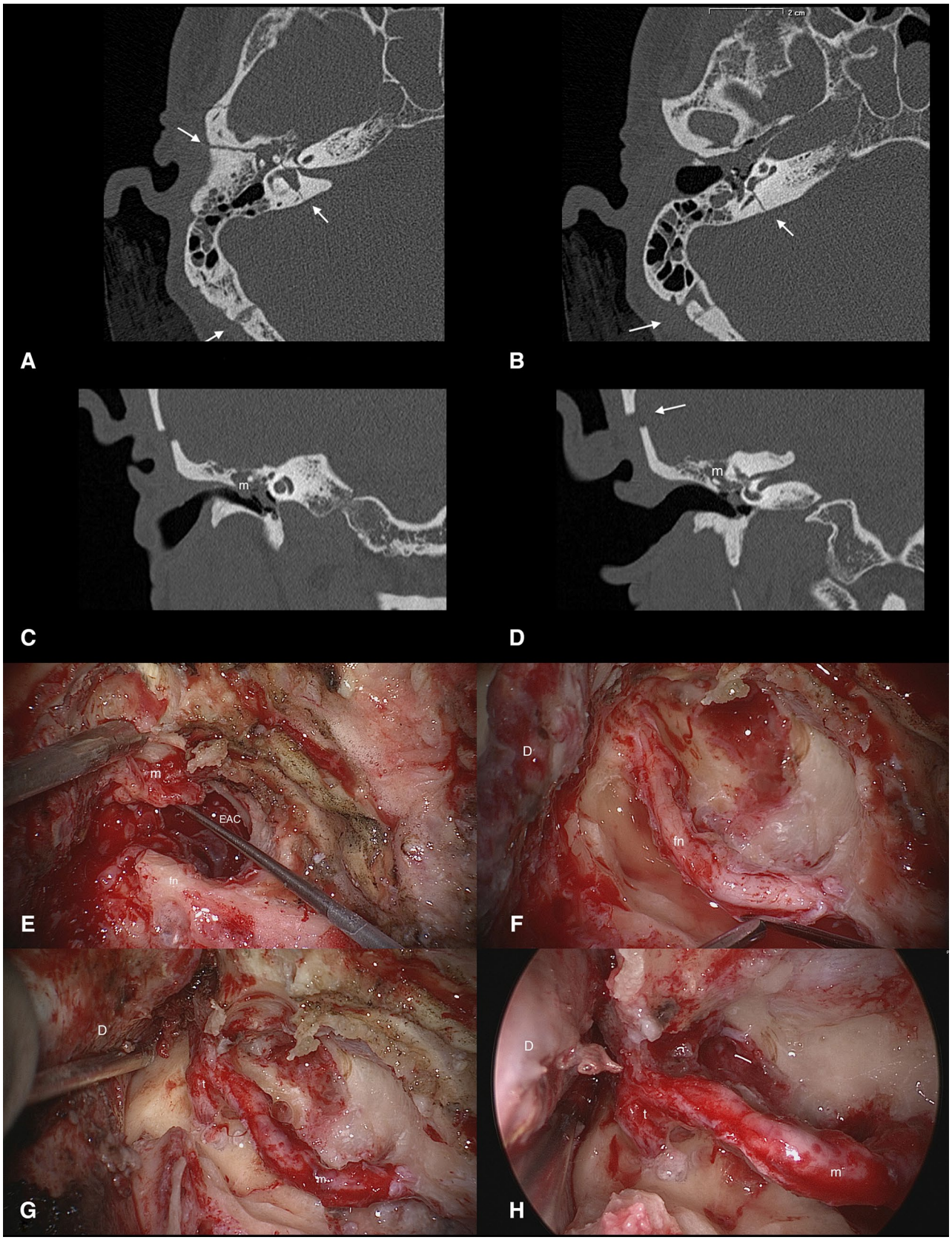
A MCF approach was performed in attempt to preserve residual hearing, although the cholesteatoma was situated very close to the cochlea (Fig. 1). An incision was made in the shape of a question mark (Fig. 1b). A cutaneous flap was prepared to reveal the temporalis muscle covered by its fascia, then the myofascial flap was elevated. An ample quadrangular craniotomy measuring about 4×4 cm was made (Fig. 1c). A drill is generally used for this step. The lower edge of the craniotomy should be at the level of the base of the zygoma to be approximately at the level of the floor of the middle cranial fossa. Elevation of the dura from the superior surface of the temporal bone was performed under microscopic magnification. The dural elevation was performed carefully and anatomic landmarks were identified: the middle meningeal artery (Fig. 1d) was coagulated and transected to provide adequate control over the petrous apex; the great petrosal nerve (Fig. 1e) was identified and sectioned; the trigeminal nerve (Fig. 1f) was identified. The arcuate eminence, the bony prominence indicating the position of the superior semicircular canal, and the cholesteatoma were all identified along the medial wall of the petrous bone (Fig. 1g). Bone drilling of the medial wall of the petrous bone was performed to circumscribe the first voluminous part of the cholesteatoma, and the internal carotid artery (ICA) was identified (Fig. 1h). The first portion of the pathology was then removed (Fig. 1i). The cholesteatoma appeared to extend to the IAC infiltrating the dura (Fig. 1j). The residual pathology was removed with delicate surgical maneuvers using ear dissectors and suction (Fig. 1k). Using a 0 degree endoscope, the final surgical field was explored and there was no evidence of residual pathology (Fig. 1l). The cochlea was preserved.

Postoperatively, both hearing function and FN function were unchanged.

Transotic approach

Rationale

The transotic approach is a lateral surgical approach through the temporal bone that permits access to the petrous apex, cerebellopontine angle (CPA), and lateral skull base. This approach entails skeletonization of the FN from the stylomastoid foramen to the geniculate ganglion, maintaining the medial aspect of the fallopian canal, which represents the main support to the nerve at the end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◂**Fig. 2** Preoperative CT scan and Facial nerve decompression. Transmastoid-transotic approach. Right ear. **a**, **b** Fracture lines (white arrows) passing through the temporal squama, the mastoid and crossing the semicircular canals. **c**, **d** Fracture line across the temporal squama (white arrow) and meningocele occupying the tympanic cavity. *m* meningocele. **e** The meningocele (m) protruding into the external auditory canal (EAC). *fn* facial nerve. **f** After a canal-wall-down mastoidectomy, labyrinthectomy and drilling of the cochlea, the third portion of the facial nerve was skeletonized (fn). The bone canal was completely opened and the perineural sheath removed. Dehiscent dura of the middle cranial fossa (D). **g** After a temporal craniotomy, decompression of the tympanic portion of the facial nerve (t). *m* mastoid portion. Dehiscent dura of the middle cranial fossa (D). **h** Endoscopic view of the facial nerve completely decompressed in its tympanic (t) and mastoid (m) portions. Dehiscent dura of the middle cranial fossa (D)

of the procedure. No FN rerouting is performed in this approach [9].

Case presentation

A 46-year-old man developed a right facial palsy grade V (H–B scale) after a head trauma due to an accidental fall on stairs. Audiological evaluation showed complete hearing loss on the right side, normal hearing function on the left side. CT scans showed temporal fractures involving the temporal bone with a fracture line passing through the temporal squama, the mastoid and crossing the semicircular canals. The tympanic cavity appeared to be occupied by a meningocele (Fig. 2).

A transotic approach with a craniotomy was performed (Fig. 2e–h). A "C" shaped retroauricular skin incision was made extending to the temporal region with the creation of cutaneous and myoperiosteal flaps exposing the temporal squama. The fracture line involved the roof of the external auditory canal (EAC), occupied by a meningocele, and the mastoid crossing the third portion of the FN which, at this level, was dehiscent and apparently injured and extending forward to the geniculate ganglion. A large mastoidectomy was performed and the posterior wall of the EAC was drilled. After the labyrinthectomy and drilling of the cochlea, the third portion of the FN was skeletonized, the bone canal was completely opened and the perineural sheath was removed from the geniculate ganglion to the stylomastoid foramen. Then a temporal craniotomy was performed. Following the superior surface of the temporal bone as far as the arcuate eminence, the tympanic portion of the FN was identified and decompressed with the help of a 0° endoscope. Collagen implant derived from lyophilized bovine pericardium and surgical sealant film grafts was used to repair the dural plane.

6 months after surgery, the FN function was grade IV according to the H–B scale.

Transmastoid translabyrinthine approach

Rationale

Compared to the two approaches described above, the transmastoid translabyrinthine approach allows direct access to the whole temporal portion of the FN. It is indicated for pathology involving the mastoid, the middle ear and the FN in its tympanic and mastoid portions. With endoscopic assistance and after removal of the labyrinth, all of the aspects of the geniculate ganglion and the labyrinthine segment as far as the IAC can be visualized and controlled avoiding the need for a craniotomy.

We present two cases, the first, an endoscopic-assisted transmastoid translabyrinthine approach and the second, a simple translabyrinthine approach with positioning of a cochlear implant (CI).

Case presentation

A 39-year-old man was referred to our clinic for a left a FN palsy (grade III according to the H–B scale) arised 1 year earlier. He underwent a tympanoplasty on the right side 15 years earlier. The CT scan (Fig. 3) showed a cholesteatoma involving the petrous apex, the middle ear and the FN at the level of the geniculate ganglion and the tympanic and labyrinthine portions as far as the fundus of the IAC. The audiogram showed a bilateral symmetric conductive hearing loss (PTA AC 40 dB and BC 10 dB bilaterally).

An endoscopic-assisted transmastoid translabyrinthine approach was performed. A canal-wall-down mastoidectomy was performed identifying the classic landmarks: dura, middle cranial fossa (MCF), sigmoid sinus (SS) (Fig. 3c). After removal of the tympanic membrane and residual ossicular chain, the cholesteatoma involving the middle ear and tympanic FN was identified (Fig. 3d, e). Decompression of the FN was carried out using delicate surgical maneuvers (Fig. 3f). Dissection of the temporal bone was performed by drilling using microscopic magnification, and following the pathology extension. The cholesteatoma appeared to involve the most anterior portion of the tympanic FN, the geniculate ganglion, and it extended towards the fundus of the IAC. Using a diamond burr and rounded instruments, the pathology was progressively dissected from the FN (Fig. 3g). Under endoscopic magnification, the hidden areas of the surgical field were checked and radicalization was performed using a diamond burr (Fig. 3h). The geniculate ganglion was skeletonized circumferentially (Fig. 3i–k) and the complete course of the temporal FN was seen, from the mastoid segment to the IAC (Fig. 3i–k).

3 months after surgery the FN function on the left side was I grade according to the H–B scale.

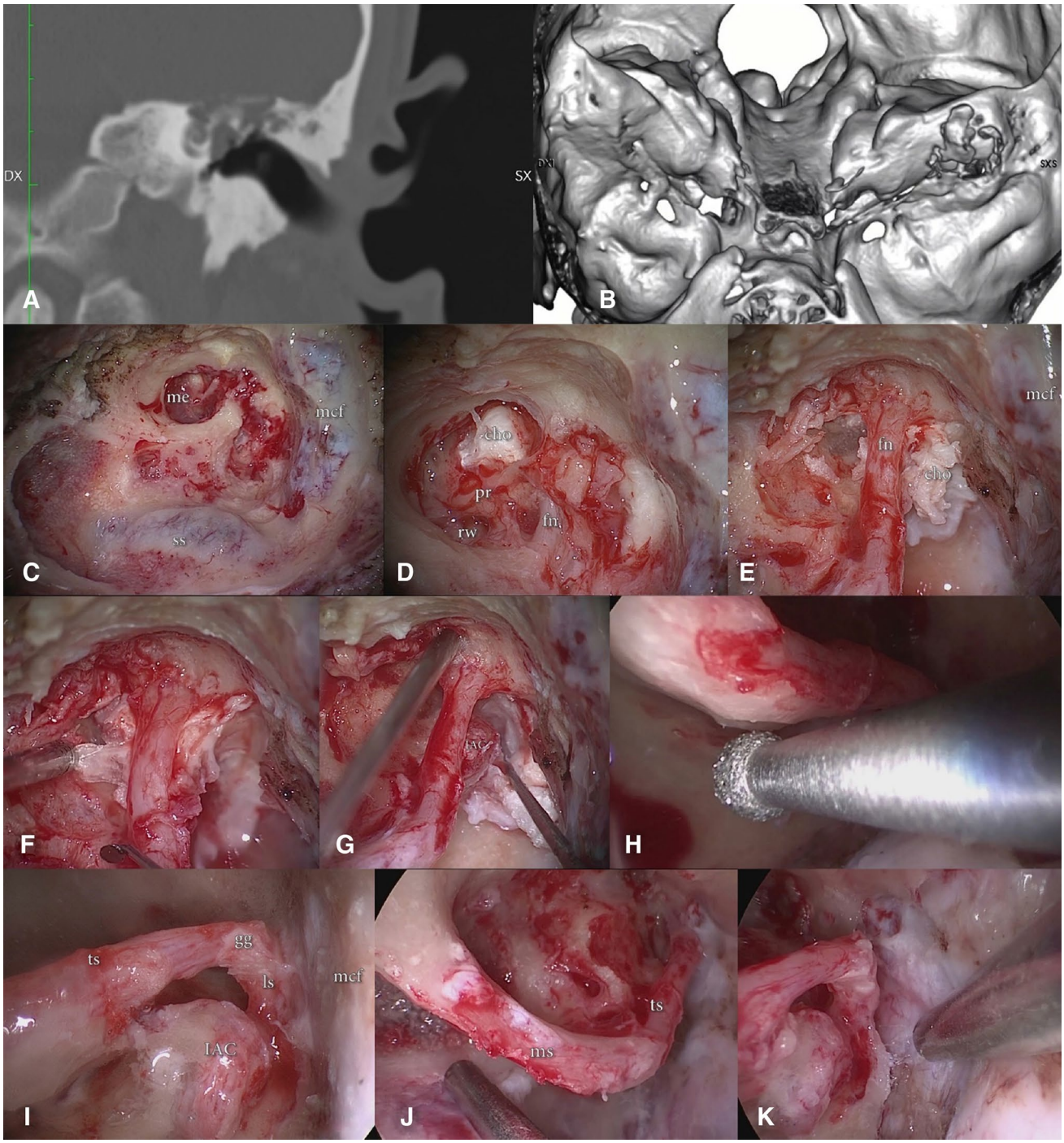


Fig. 3 Endoscopic-assisted translabyrinthine approach. Left ear. **a** CT scan; **b** 3D reconstruction (right panel) showing the extension of the pathology to the medial aspect of the petrous bone, the geniculate ganglion, the middle ear, and the labyrinthine and tympanic portions of the facial nerve. **c** Canal-wall-down mastoidectomy; *me* middle ear, *ss* sigmoid sinus, *mcf* middle cranial fossa; **d** the cholesteatoma occupying the middle ear, *cho* cholesteatoma, *fn* facial nerve, *rw* round window, *pr* promontory; **e** the tympanic facial nerve invaded by the pathology; **f** dissection of the nerve; **g** *IAC* internal auditory canal; **h** endoscopic radicalization with drill; **i** endoscopic view of the temporal course of the nerve, *ts* tympanic segment, *gg* geniculate ganglion, *ls* labyrinthine segment; **j** *ms* mastoid segment, *ts* tympanic segment; **k** final endoscopic view

A female patient, 85 years old, affected by a recurrence of cholesteatoma in the right ear. She underwent a canal-wall-down tympanoplasty for cholesteatoma 15 years before. Normal facial function bilaterally. Audiological evaluation: complete hearing loss on the right side, mild sensorineural hearing loss on the left side (PTA AC 55 dB, BC 48 dB). CT scans indicated the recurrence of cholesteatoma completely invading the cavity of the previous mastoidectomy and the tympanic portion of the FN. An interruption of the tegmen tympani and a fistula in the lateral semicircular canal (LSC) were present on the right side (Fig. 4a–d).

A translabyrinthine surgical approach with the placement of a CI 512 on the right side was done (Fig. 4e–h). After the incision and "cul de sac" closure of the EAC, the recurrence of cholesteatoma was identified. A revision of the mastoidectomy was performed after identifying the classic landmarks. The anterior wall of the EAC was drilled exposing the temporomandibular joint. The cholesteatoma appeared to involve the tympanic segment of the FN and it was carefully dissected from the nerve maintaining its integrity. After removal of the pathological tissue, a fistula was identified in the LSC and the stapedial platina was significantly eroded. A translabyrinthine approach was performed. The third segment of the FN was completely skeletonized, and the jugular bulb exposed, appearing partially dehiscent. After the placement of the receiver–stimulator complex of the implant, the round window was identified, and the array was inserted. Correct positioning of the implant was confirmed by audiological testing and the normal activity of the facial nerve was verified with electrophysiological stimulation.

The postoperative FN function was preserved. A good speech perception on the right side was achieved.

Transcanal totally endoscopic approach (TTEA)

Rationale

The EAC forms a natural corridor to the middle ear. Recently, increased experience in endoscopic middle ear surgery has permitted the use of an exclusive transcanal approach for the treatment of pathology involving the tympanic portion of the FN, the geniculate ganglion and the supragenicular fossa [6].

The advantage of this approach is the direct and minimally invasive exposure of the tympanic FN and the geniculate ganglion area with lower morbidity compared with traditional approaches which may lead to CSF leakage or temporal lobe traction. The disadvantages include the necessity to partially remove the ossicular chain and then to perform an ossiculoplasty, with variable audiological outcomes. However, when a dural repair is needed, a combined endoscopic and microscopic approach is mandatory [10].

Case presentation

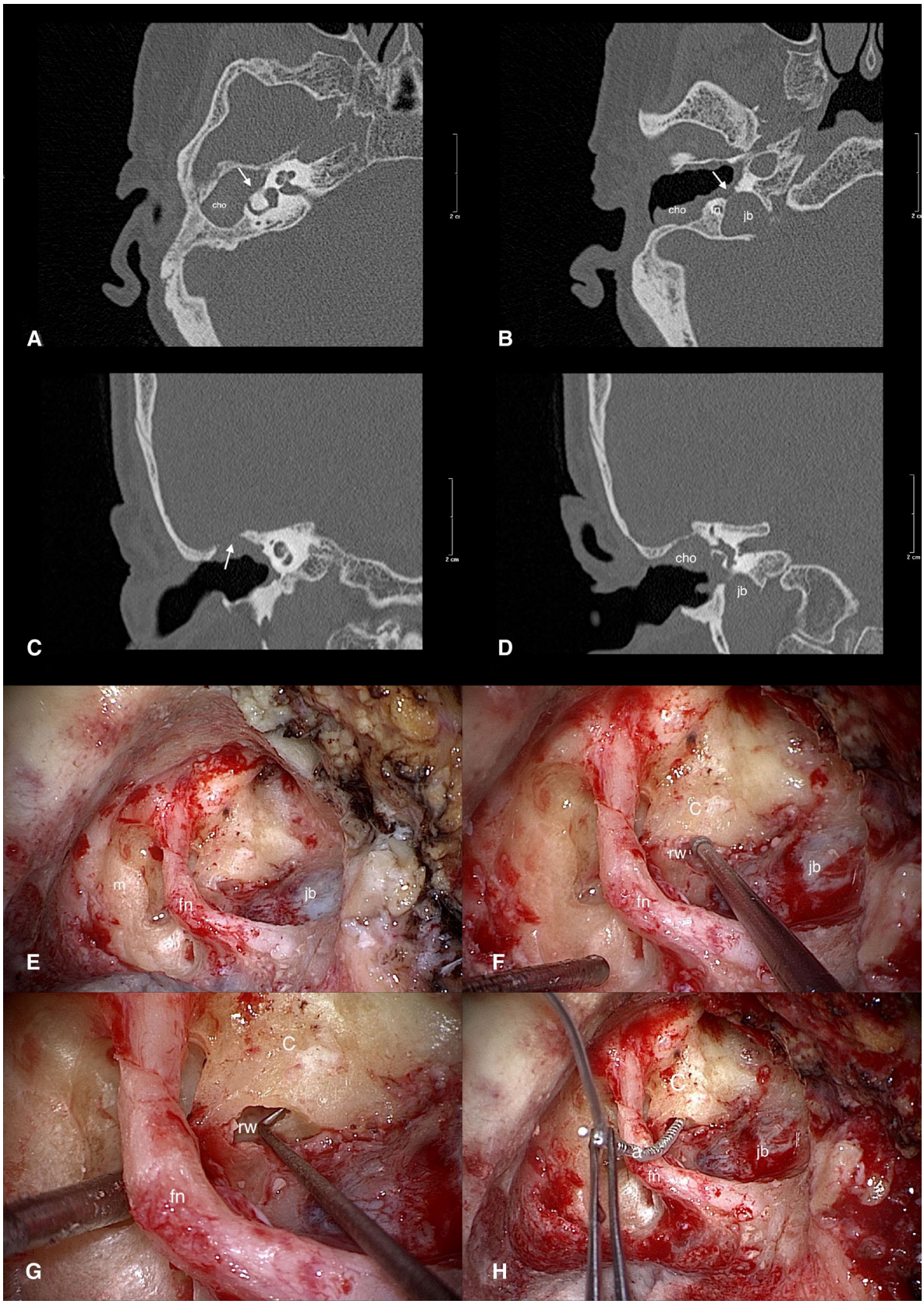
A 35-year-old man suffered cranial trauma after a motorcycle accident. At the ENT evaluation, he had facial palsy grade IV (according to the H–B classification), a hemotympanum and otorrhagia on the right side. Audiological evaluation revealed bilateral conductive hearing loss of mild grade to the right side (PTA AC 52 dB, BC 10 dB) and low grade to the left side (PTA AC 30 dB, BC 10 dB). A CT scan showed multiple fracture lines involving the geniculate ganglion area (Fig. 5a).

A transcanal endoscopic decompression of the tympanic portion of the FN was performed. In otoendoscopy using a 0° endoscopic view, a wide tympanomeatal flap was created after incision of the skin of the EAC from 11 to 6 o'clock using a molecular resonance scalpel. After removal of the flap, a fracture of the posterior portion of the EAC was evident and the middle ear appeared occupied by organized hematoma (Fig. 5b). The ossicular chain appeared displaced and disjointed. The head of the malleus and the incus had to be removed to gain direct access to the entire tympanic segment of the FN (Fig. 5c–e). Dissection of the tensor tympani muscle and its anterior translation was necessary to obtain a wide view of the geniculate ganglion area (Fig. 5f, g). The nerve appeared to be compressed by a bone fragment at the level of the geniculate ganglion. The bony fragment was removed (Fig. 5h, i). Removal of the bony canal of the nerve was carried out using a curette to achieve decompression of the nerve from the geniculate ganglion to the second genu (Fig. 5j–l). Using a drill, an ossiculoplasty was performed with the remodeled incus positioned between the handle of malleus and the stapes (Fig. 5m). Absorbable haemostatic gelatin sponge soaked with steroids was placed near the nerve and supported the reconstruction. Myringoplasty was performed using heterologous material. Figure 5n, o shows the tonal audiogram before and after surgery. It shows an improvement of the hearing function with a postoperative PTA AC 30 dB (52 dB preoperatively).

The FN function improved, reaching the II grade according to the H–B scale 6 months after surgery.

Discussion

FN anatomy is extremely complex. Different pathologies can spread or can involve the FN in all its course, from its origin into the brainstem to the peripheral branches. A careful analysis of symptoms and a preoperative study with CT scan and MRI are crucial to make a diagnosis and to plan the best surgical approach. Different surgical approaches are possible, with specific indications, contraindications and results and the choice of surgery is made based on the portion of the nerve involved, the type and extent of the pathology, the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◂**Fig. 4** Preoperative CT scan. Subtotal petrosectomy, and translabyrinthine approach with placement of a cochlear implant. Right ear. **a** Recurrence of cholesteatoma (cho) completely invading the cavity of the earlier mastoidectomy. Fistula in the lateral semicircular canal (white arrow). **b** Cholesteatoma (cho) invading the tympanic portion of the facial nerve (fn). Dehiscence of the jugular bulb (jb). Fistula in the lateral semicircular canal (white arrow). **c** Interruption of the tegmen tympani (white arrow). **d** Cholesteatoma (cho). Dehiscence of the jugular bulb (jb). **e** After the subtotal petrosectomy and labyrinthectomy (m), the third segment of the facial nerve (fn) is completely skeletonized and the jugular bulb exposed (jb), appearing partially dehiscent. **f**, **g** Identification of the cochlea (C) and the round window (rw) and cochleostomy. **h** Insertion of the array (*a*)

possibility of hearing preservation and the encasement of the ICA. In this article, some different surgical approaches to the FN are showed: the MCF approach, the transotic, the translabyrinthine, and the TTEA.

MCF approach

Advantages:

- Optimal exposure of the perigeniculate and labyrinthine portions of the FN.
- Hearing preservation.

Disadvantages:

- Difficult anatomy.
- Temporal lobe retraction, with possible complications such as brain edema or contusion, subdural hematoma, cerebrospinal fluid (CSF) leak, or meningitis.

The MCF approach provides access to the FN from the cisternal to the proximal tympanic segments, while allowing the preservation of auditory and vestibular function. The labyrinthine segment of the fallopian canal is the narrowest segment along the entire course of the facial nerve, measuring 0.69 mm in diameter on average and a tight arachnoid band is present at the proximal extent of the labyrinthine segment of the fallopian canal and acts as a chokepoint of constriction in the setting of edema [11, 12]. Based on these considerations, one of the indications for this surgery is FN decompression in Bell's palsy. For the first time Fisch and Esslen [13] used a MCF approach to perform FN decompression on a series of patients with Bell palsy and found pronounced edema and vascular injection of nerve proximal to the geniculate ganglion in 11 out of 12 patients. Nowadays, this approach is also commonly used to reach the medial portion of the temporal bone and the safety and efficacy has been demonstrated in numerous studies to approach tumors of the FN, remove acoustic neuromas, cholesteatomas and repair superior canal dehiscence [14, 15]. Focussing on FN pathology, indications for this approach include neoplastic lesions involving the geniculate ganglion area and decompression of the I and II segments caused by cholesterol granuloma, cholesteatoma or after temporal bone fractures. Risks associated with MCF surgery include cerebrospinal fluid (CSF) leak, meningitis, and complications associated with temporal lobe retraction (e.g., aphasia, seizure), so this approach should be performed in experienced hands.

Transotic approach

Advantages:

- The complete infralabyrinthine compartment of the temporal bone is used, from the carotid artery to the sigmoid sinus, and from the jugular bulb to the superior petrosal sinus.
- It's the largest possible transtemporal access to the CPA.
- The preservation of the FN in its anatomic position within the fallopian canal, maintaining its vascularization, does not limit the visibility or illumination.

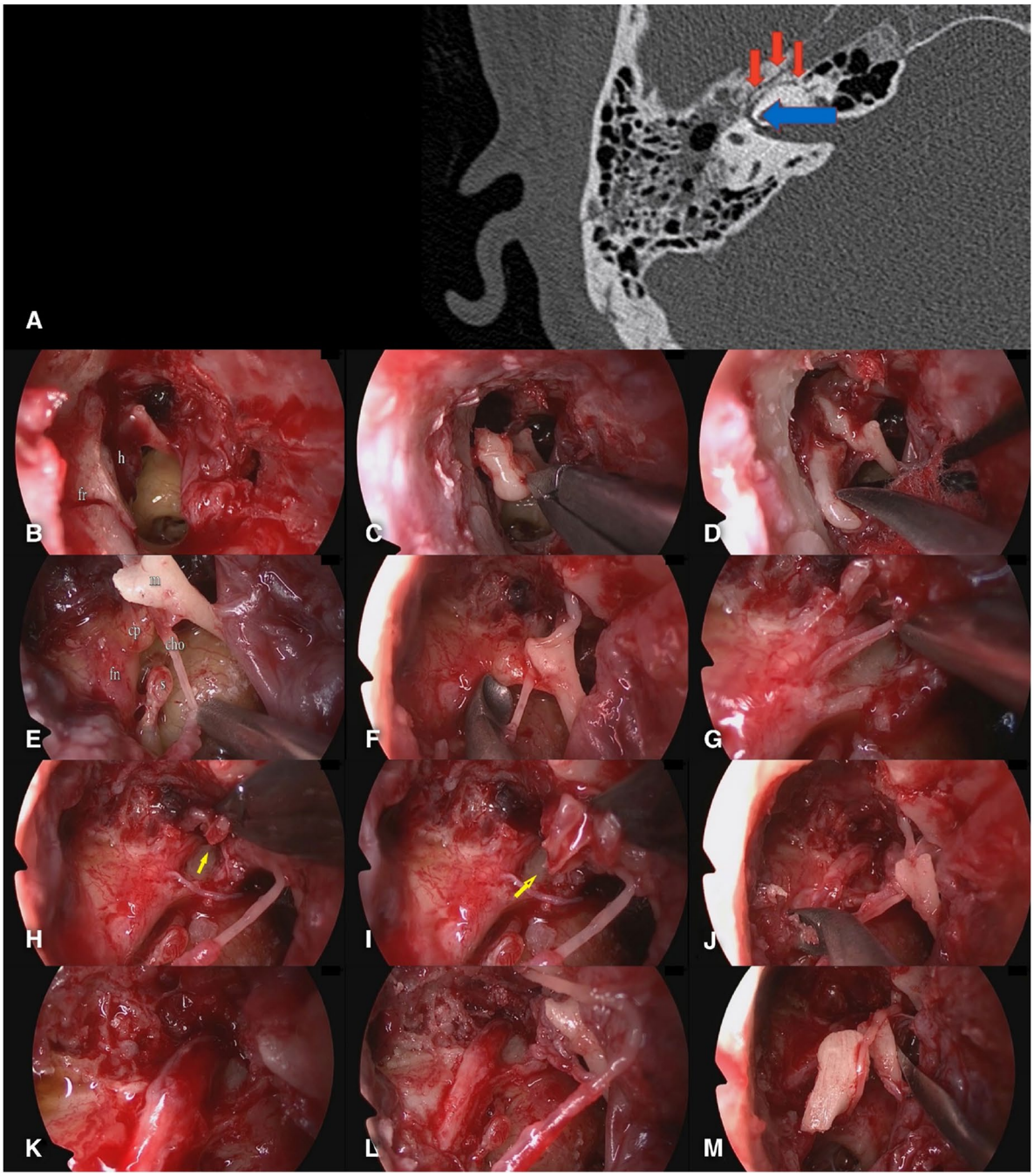
Disadvantages:

- Sacrifice of the otic capsule, with hearing loss and transient vestibular disfunction.

In the 1970s, Ugo Fisch developed the transotic approach [16, 17] to avoid three main limitations inherent in the translabyrinthine approach [9] for acoustic neuromas surgery: (1) the reduction of surgical exposure given by the preservation of the middle ear spaces in cases of not favorable anatomical conditions (reduced pneumatization, anterior location of the sigmoid sinus, high jugular bulb and low middle cranial fossa dura); (2) the difficulty in exposing the anterior CPA and, therefore, in separating and preserving under direct vision the intracranial segment of the FN from the anterior pole of the tumor; and (3) the danger of postoperative CSF leakage and meningitis due to the direct contact of the intact middle ear mucosa with the subarachnoid space in the operated mastoid cavity [9]. Other lesions involving the CPA or the temporal bone with invasion of the IAC or the otic capsule could also be approached via the transotic technique. These lesions include the following: epithelial cysts (congenital cholesteatoma), arachnoid cysts, hemangiomas, giant cholesterol and mucosal cysts, jugular foramen schwannomas, temporal paragangliomas (glomus tumors). These lesions can be quite extensive and may require a combined infratemporal fossa type A or B approach for added exposure.

Translabyrinthine approach

Advantages: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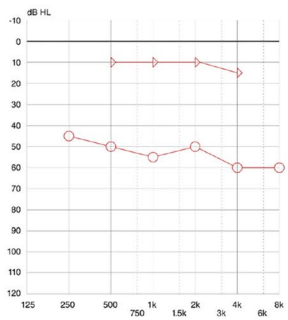
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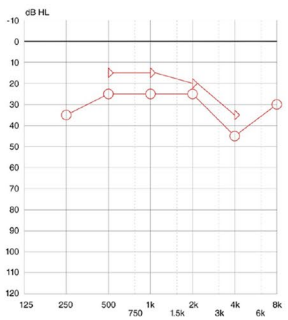
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◂**Fig. 5** Endoscopic transcanal decompression of the facial nerve. Right ear. **a** preoperative CT scan. Red arrows, line of fractures involving the geniculate ganglion area. Blue arrow, geniculate ganglion. **b** fracture (fr) of the posterior wall of the external auditory canal (EAC). *h* hematoma. **c** Removal of the head of malleus. **d** Removal of the incus. **e** *fn* Facial nerve, *cp* cochleariform process, *cho* chorda tympani, *s* stapes, *m* handle of malleus. **f**, **g** Fracture of the cochleariform process and anterior transposition of the tensor tympani muscle. **h**, **i** Removal of a bony fragment (yellow arrow) compressing the geniculate ganglion. **j**–**l** Removal of the bony canal and final view of the decompressed nerve. **m** Ossiculoplasty with remodeled incus. Auditory threshold before (**n**) and after (**o**) surgery

- It is the most direct route to the structures of the CPA.
- The lateral end of the IAC can be dissected to ensure complete tumor removal from this area, and to allow consistent anatomic identification of the FN.
- Exposure of the mastoid, tympanic and labyrinthine portions of the FN.
- The FN is readily accessible from the brainstem to the stylomastoid foramen and beyond into the parotid gland.

Disadvantages:

- Hearing sacrifice

One the most important indications for translabyrinthine approach is the surgical treatment of vestibular shwannoma. In the 1960s, William F. House developed the translabyrinthine approach [18] which became very popular because it reduced the mortality of vestibular schwannoma extirpation from 20% (neurosurgical approaches) to 2%. The total loss of hearing was accepted in view of the radical removal of the tumor combined with better preservation of facial function with dramatically reduced postoperative morbidity and mortality [19]. It is also ideal for FN lesions, such as neuromas; trauma owing to operative injury or head trauma. In addition to vestibular schwannoma removal, the translabyrinthine craniotomy approach is used for other tumors (e.g., meningiomas, cholesteatomas involving the petrous bone and posterior fossa, cholesterol granulomas, glomus tumors, and adenomas), for decompression of the FN, and for repair of the FN by either direct end-to-end anastomoses or nerve grafting. Unlike in the transonic approach, the preservation of the cochlea provides the possibility to place a CI.

Transcanal totally endoscopic approach

Advantages:

- Direct and minimally invasive exposure of the tympanic FN and the geniculate ganglion area, with lower morbidity compared with traditional approaches

Disadvantages:

- Ossicular chain removal, an ossiculoplasty is required at the end of surgery.
- When a dural repair is needed, a combined endoscopic and microscopic approach is necessary.

The anatomy of the tympanic portion of the FN was clarified thanks to the endoscopic approach to the middle ear. Endoscopically, it is important to distinguish two portions of the FN: the precochleariform segment, lying superiorly and anteriorly to the posterior bony limit of the cochleariform process; the postcochleariform segment lying posteriorly to this landmark. The postcochleariform segment runs parallel to the LSC, the latter representing an important landmark for reaching the aditus ad antrum with an endoscopic technique [20]. The geniculate ganglion lies between the medial wall of the attic laterally, the antero-lateral portion of the vestibule posteriorly, the middle cranial fossa superiorly and the cochlea infero-medially. For these considerations, endoscopic transcanal FN decompressionis applicable in case of post traumatic facial palsy, in particular, when there is an involvement of the geniculate ganglion region. The endoscopic approach permits also some endoscopic approaches to lateral skull base, with specific pros and cons. The transpromontorial approach allows eradication of lesions involving fundus of internal auditory canal and petrous apex, with limited extension to the intracochlear, intravestibular, and pericarotid regions [21]. The supragenicular approach allows eradication of pathologic conditions involving the triangular area between geniculate ganglion inferiorly, middle cranial fossa dura superiorly, and labyrinthine bloc posteriorly [3, 9].

Conclusion

FN surgery requires excellent surgical versatility and knowledge, and different instruments are useful to manage all possible clinical settings. Excellent knowledge of this anatomy is crucial for ENT specialists. Anatomical study, associated with a correct neuroradiological assessment is mandatory for surgical planning. In fact, depending on the localization of the pathology, clinical findings and patient's comorbidity, different approaches can be used with the possibility of preservation of hearing and the vital structures involved (e.g., ICA). Next to microscopic surgery, the introduction of the endoscope, used exclusively or in combined approaches, helps the surgeon to develop innovative surgical approaches [6, 22], with lower comorbidity when compared with traditional surgery.

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Compliance of ethical standards

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

Ethical approval This article does not contain any study with human participants or animals performed by any of the authors.

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