The Gruppo Otologico Approach to Tympanojugular Paragangliomas

We emphasize that the degree of ICA involvement is the critical point in determining the surgical approach. The most accurate way in which to communicate the degree of ICA involvement...
is to stage TJPs using the Fisch classification. It is our opinion that only selected cases of Class C1 tumors can be safely and adequately addressed without rerouting of the facial nerve. We present the classic ITFA for Class C1 and certain Class C2 tumors and the ITFA with extensions as a simplified and unified paradigm in the approach to manage Class C2–C4 tumors.

### Infratemporal Fossa Approach Type A

(See also Chapter 2.)

This approach is designed to allow access to the JF area, the infralabyrinthine and apical compartments of the petrous bone, the vertical segment of the ICA, and the upper jugulocarotid space (Fig. 9.1a). The approach is designed primarily for extensive extradural lesions involving these areas. The key point in this approach is the anterior transposition of the facial nerve, which provides optimal control of the infralabyrinthine and jugular foramen regions, as well as the vertical portion of the ICA (Fig. 9.1b). The other structures that prevent lateral access to these areas are shown in Fig. 9.1c. Besides the facial nerve they include the tympanic bone, the digastric muscle, and the styloid process. These structures are removed to allow unhindered lateral access.

### Surgical Anatomy

- The mastoid segment of the facial nerve is centered on the jugular bulb. In 60% of cases, half or more of the bulb lies anterior to the vertical plane of the nerve (Fig. 9.2).
- When they exit from the skull base, the glossopharyngeal nerve is the most lateral, while the hypoglossal nerve is most medial. The hypoglossal nerve turns inferiorly to run together with the vagus nerve for a short distance in the upper neck (Fig. 9.3).
- The glossopharyngeal nerve is seen crossing the ICA anteriorly (Fig. 9.3).
- More inferiorly, the hypoglossal nerve crosses the artery to go toward the tongue. The vagus nerve is seen coursing between the internal jugular vein and the ICA (Fig. 9.4). The accessory nerve crosses the lateral surface of the internal jugular vein and travels posteriorly.
- In half of cases, the spinal accessory nerve crosses medial to the internal jugular vein. In all cases, it passes anterolateral to the transverse process of the atlas (Fig. 9.5).
- Note the close relation between the vertebral artery and the internal jugular vein. TJPs with considerable extension into the neck may well involve the artery (Fig. 9.5).
- The styloid process and its muscles separate the external carotid artery laterally from the ICA medially.
- The condylar emissary vein drains into the jugular bulb in 70% of cases, and the vein often has an intimate relation to the lower cranial nerves (X–XI) at their exit from the JF (Fig. 9.6).
- After its origin from the external carotid artery, the occipital artery runs backward, lateral to the internal jugular vein and the accessory nerve in the neck. The ICA angles medially at its ingress into its bony canal at the skull base. The jugular bulb curves laterally before its exit into the neck to form the internal jugular vein (Fig. 9.7).
- Fig. 9.1c shows the structures passing lateral to the great vessels at the base of the skull: the facial nerve, and the styloid process and its attached ligaments and muscles, as well as the posterior belly of the digastric muscle and sternocleidomastoid muscle. For extensive jugular foramen tumors extending down to the neck, as in Class C TJPs, adequate control of this region from the lateral to medial aspect requires these structures to be either sacrificed or transposed.

### Surgical Steps

1. A postauricular skin incision is made (Fig. 9.8).
2. A small, anteriorly based musculoperiosteal flap is elevated to help in closure afterward. The EAC is transected as before (Fig. 9.9).
3. The facial nerve is identified at its exit from the temporal bone (Fig. 9.10). The main trunk is found at the perpendicular bisection of a line joining the cartilaginous pointer to the mastoid tip. The main trunk is traced in the parotid until the proximal parts of the temporal and zygomatic branches are identified.
4. The posterior belly of the digastric muscle and the sternocleidomastoid muscle are divided close to their origin. The internal jugular vein and the external and internal carotid arteries are identified in the neck (Fig. 9.9). The vessels are marked with vessel loops.
5. The skin of the external auditory canal, the tympanic membrane, the malleus, and incus are removed.
6. A canal wall down mastoidectomy is performed, with removal of the bone anterior and posterior to the sigmoid sinus. The facial nerve is skeletonized from the stylomastoid foramen to the geniculate ganglion. The last shell of bone is removed using a double-curved raspatory. The suprastructure of the stapes is preferably removed after cutting its crura with microscissors (Fig. 9.11).
7. The inferior tympanic bone is widely removed, and the mastoid tip is amputated using a rongeur. A new bony canal (arrow in Fig. 9.12) is drilled in the root of the zygoma superior to the Eustachian tube.
8. The facial nerve is freed at the level of the stylomastoid foramen using strong scissors. The soft tissues at this level are not separated from the nerve (Fig. 9.13).
9. The mastoid segment is next elevated using a Beaver knife to cut the fibrous attachments between the nerve and the fallopian canal. The tympanic segment of the nerve is elevated carefully, using a curved raspatory, until the level of the geniculate ganglion is reached. A nontoothed forceps is used to hold the soft tissue surrounding the nerve at the stylomastoid foramen, and anterior rerouting is carried out (Fig. 9.14).
10. A tunnel is created in the parotid gland to lodge the transposed nerve (Fig. 9.15). The tunnel is closed around the nerve using two sutures.
11. A closer view (Fig. 9.16) shows the facial nerve in its new bony canal, just superior to the Eustachian tube. The nerve is fixed to the new bony canal using fibrin glue.
12. Drilling of the infralabyrinthine cells is completed, and the vertical portion of the ICA is identified (Fig. 9.17).
13. The mandibular condyle is separated from the anterior wall of the external auditory canal using a large septal raspatory. The Fisch infratemporal fossa retractor is applied, and the mandibular condyle is anteriorly displaced, with care being taken
Fig. 9.1a–c Illustrations for infratemporal fossa approach type A (ITFA).

a An illustration of the surgical view in ITFA.
b An illustration of the surgical limit in ITFA.
c An illustration of obstacles to approaching the jugular bulb.

AFL anterior foramen lacerum
C1 atlas
C2 axis
Ch cochlea
DM posterior belly of the digastric muscle
ICA internal carotid artery
IJV internal jugular vein
JB jugular bulb
LSM levator scapulae muscle
Lv vein of Labbé
mma middle meningeal artery
M mandible
OC occipital condyle
P parotid gland
pc clinoid process
pp pterygoid plate
SCM sternocleidomastoid muscle
SP styloid process
SPCM splenius capitis muscle
sph sphenoid sinus
sps superior petrosal sinus
TP transverse process of the atlas
TS transverse sinus
V2 maxillary branch of the trigeminal nerve
V3 mandibular branch of the trigeminal nerve
za zygomatic arch
VA vertebral artery
VII facial nerve
IX glossopharyngeal nerve
XI spinal accessory nerve
XII hypoglossal nerve
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Fig. 9.8 Incision for infratemporal fossa approach type A.

Fig. 9.9
- DM: digastric muscle
- EAC: external auditory canal
- ECA: external carotid artery
- FN: facial nerve
- ICA: internal carotid artery
- IX: glossopharyngeal nerve
- XI: spinal accessory nerve
- XII: hypoglossal nerve

Fig. 9.10
- EAC: external auditory canal
- FN: facial nerve

Fig. 9.11
- FN: facial nerve
- Isc: lateral semicircular canal
- PFD: posterior fossa dura
- Psc: posterior semicircular canal
- Ssc: superior semicircular canal
- StF: stylomastoid foramen

Fig. 9.12
- Co: cochlea
- FN: facial nerve
- JB: jugular bulb
- Isc: lateral semicircular canal
- PFD: posterior fossa dura
- Psc: posterior semicircular canal
- StF: stylomastoid foramen

Fig. 9.13
- ET: eustachian tube
- FN: facial nerve
- StF: stylomastoid foramen

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not to injure the facial nerve. The anterior wall of the external auditory canal is further drilled, thus completing the exposure of the vertical portion of the ICA. A small incision is made in the posterior fossa dura just behind the sigmoid sinus, through which an aneurysm needle is passed. Another incision is made just anterior to the sinus to allow for the exit of the needle (Fig. 9.18).

14. The sinus is closed by double ligature with a Vicryl suture (Fig. 9.19). Suture closure of the sinus, however, may lead to gaps in the dural incision, with a higher risk of cerebrospinal fluid leakage postoperatively. Alternatively, the sigmoid sinus can be closed with extraluminal Surgicel® packing (Fig. 9.20).

15. The structures attached to the styloid process are severed. The styloid is fractured using a rongeur, and is then cut with strong scissors (Figs. 9.21, 9.22).

16. The remaining tough fibrous tissue surrounding the ICA at its ingress into the skull base is carefully removed using scissors (Fig. 9.23).

17. The internal jugular vein in the neck is double ligated and cut or closed with vascular clips (the easier and faster method) (Fig. 9.24).

18. The vein is elevated superiorly, with care being taken not to injure the related lower cranial nerves (Figs. 9.25, 9.26). In cases in which the eleventh nerve passes laterally, the vein has to be pulled under the nerve carefully to prevent it from being damaged.

19. If necessary the lateral wall of the sigmoid sinus can be removed (Fig. 9.27). Removal continues down to the level of the jugular bulb.

20. The lateral wall of the jugular bulb is opened. Bleeding usually occurs from the apertures of the inferior petrosal sinus and the condylar emissary vein. This is controlled with Surgicel® packing (Fig. 9.28).

21. If there is limited intradural extension, the dura is opened without injury to the endolymphatic sac (Fig. 9.29).

22. Figures 9.30–9.32 show the view after the dura of the posterior fossa has been opened.
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**Fig. 9.18**
- Co: cochlea
- ICA: internal carotid artery
- JB: jugular bulb
- PFD: posterior fossa dura

**Fig. 9.19**
- JB: jugular bulb
- PFD: posterior fossa dura

**Fig. 9.20**
This is the technique of extraluminal closure of the sigmoid sinus to avoid the risk of CSF leakage with suture of the sigmoid sinus.

- IJV: internal jugular vein
- MFD: middle fossa plate

**Fig. 9.21**
- IJV: internal jugular vein

**Fig. 9.22**
- FN: facial nerve
- ICA: internal carotid artery
- IJV: internal jugular vein

**Fig. 9.23**
- Co: cochlea
- FN: facial nerve
- ICA: internal carotid artery
- IJV: internal jugular vein
23. At the end of the procedure, the eustachian tube (Fig. 9.33) is closed with a piece of muscle. The dural opening is closed with a muscle plug or with only abdominal fat. We never use a rotated temporalis muscle flap (as suggested by Fisch), so as to avoid aesthetic problems, but the sternocleidomastoid muscle and the digastric muscle are sutured together and the temporalis muscle is left in its place.

### Extensions of the Infratemporal Fossa Approach Type A

Based on the ITFA, various extensions are dictated by the extent of the pathology. The standard extension we use is a transcondylar, transtubercular extension for C2–C4 tumors. This allows additional posteroinferior and medial access to the JF, widening the exposure, thus facilitating venous and neural control. The widened angle also affords better access to the petrous apex, medial to the carotid artery. Very rarely a far-lateral approach is employed with full exposure of the vertebral artery. The use of a translabyrinthine extension is occasionally required for otic capsule involvement. A modified transcochlear approach is uncommonly required to access the petrous apex, clival involvement, and infratemporal fossa involvement:
- Transcondylar, transtubercular extension improving postero-inferolateral and medial exposure at the first stage (Fig. 9.34)
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**Fig. 9.28**
- Co: cochlea
- FN: facial nerve
- ICA: internal carotid artery
- ips: inferior petrosal sinus
- Isc: lateral semicircular canal
- PFD: posterior fossa dura
- psc: posterior semicircular canal
- IX: glossopharyngeal nerve
- X: vagus nerve

**Fig. 9.29**
- Cbl: cerebellum
- Co: cochlea
- ELS: endolymphatic sac
- ICA: internal carotid artery
- ips: inferior petrosal sinus
- psc: posterior semicircular canal
- IX: glossopharyngeal nerve

**Fig. 9.30** The glossopharyngeal and vagus nerves are well identified in the cerebellomedullary cistern before entering the jugular foramen.
- PFD: posterior fossa dura
- psc: posterior semicircular canal
- IX: glossopharyngeal nerve
- X: vagus nerve

**Fig. 9.31** The facial and vestibulocochlear nerves and the anterior inferior cerebellar artery are visible.
- AICA: anterior inferior cerebellar artery
- Co: cochlea
- ICA: internal carotid artery
- psc: posterior semicircular canal
- VIII: vestibulocochlear nerve

**Fig. 9.32** A closer view shows the anterior inferior cerebellar artery passing between the seventh and eighth nerves.
- AICA: anterior inferior cerebellar artery
- Co: cochlea
- psc: posterior semicircular canal
- VII: facial nerve
- VIII: vestibulocochlear nerve

**Fig. 9.33** The eustachian tube (ET) and the rerouted facial nerve (FN) are visible.
- Co: cochlea
• Translabyrinthine or transotic extension allowing medial and superior exposure at the second stage
• Modified transcochlear extension improving anteromedial exposure at the second stage
• Far-lateral approach further extending posteroinferolateral exposure at the second stage (Fig. 9.35) (see Chapter 18).

Transcondylar–Transtubercular Extension

The classic infratemporal fossa approach type A of Fisch permits only superior and anterior exposure of the jugular bulb and is indicated for Class C1 and certain Class C2 tumors. For larger tumor such as Class C2, C3, and C4 tumors involving the lower cranial nerves, a transcondylar–transtubercular extension is required in addition to the classic ITFA. This extension facilitates inferomedial access to the jugular bulb above the lateral mass of the atlas and occipital condyle (Figs. 9.36–9.38).

As described in the previous pages, the ITFA for TJP is based on six main surgical steps as follows.
**Surgical Steps**

**First Step (Figs. 9.39.1–9.39.6)**
- Retroauricular incision extending to the neck as a cranio-temporo-cervical approach.
- “Cul de sac” closure of the external auditory canal.
- T-shaped musculofascial incision and its posterior reflection.
- Identification and detachment of the sternocleidomastoid muscle and posteroinferior reflection.
- Identification and detachment of the posterior belly of the digastric muscle and anteroinferior reflection.
- Identification of the extratemporal facial nerve.

**Second Step (Figs. 9.39.6, 9.39.7)**
- Identification and dissection of the internal jugular vein and marking with an umbilical tape.
- Identification and dissection of the common carotid, internal carotid, and external carotid arteries. The common carotid artery is marked with an umbilical tape.
- Identification of the lower cranial nerves.

**Third Step (Figs. 9.39.8–9.39.12)**
- Removal of the skin of the external auditory canal together with tympanic membrane and ossicles.
- Subtotal petrosectomy with dissection of the middle and posterior fossa dura, dissection of the sigmoid sinus, extraluminal closure of the sigmoid sinus, and removal of the mastoid tip.
- Decompression of the facial nerve and anterior rerouting.
- Identification and removal of the styloid process.
After steps 2 and 3 of the approach, the neck and temporal bone are connected. At this point the transcondylar–transtubercular approach begins and this represents the fourth step.

**Fourth Step (Figs. 9.39.13–9.39.19)**
- Identification of the splenius capitis muscles.
- Uncovering of the posterior fossa dura toward the occipital skull base to start drilling of the jugular process and occipital condyle.
- Drilling of the jugular process and identification and drilling of the occipital condyle superior to the atlanto-occipital joint posteromedial to the jugular bulb.
- Identification of the hypoglossal canal between the jugular tubercle and occipital condyle above the vertebral artery, if indicated.
- At this point tumor removal begins.

**Fifth Step (Figs. 9.39.20–9.39.26)**
- Closure of the internal jugular vein with vascular clips.
- Dissection of the jugular vein upward after its mobilization under the spinal accessory nerve.
- Removal of the tumor from the posterior fossa dura.
- Drilling of the infiltrated bone of the fallopian canal and tympanic bone.
- Removal of tumor from the jugular bulb area.
- Drilling of the infiltrated infralabyrinthine cells.
- Opening of the sigmoid sinus for tumor removal.
- Opening of the jugular vein.
- Closure of the inferior petrosal sinus with Surgicel.
- Separation of tumor from the lower cranial nerves.
- Identification of the ICA after extensive drilling of bone and bipolar coagulation of the tumor around the artery.
- Dissection of the tumor from the artery when required.
- Further drilling of all the suspect bone of infralabyrinthine and apical cells until complete removal is accomplished.
- If required, the ICA is partially mobilized and the infiltrated clivus is drilled out.
- The posterior fossa dura is not opened and the intradural portion of the tumor is removed in a second stage.

**Sixth Step (Figs. 9.39.27, 9.39.28)**
- Meticulous hemostasis.
- Closure of the eustachian tube.
- Closure of any dural tears.
- Obliteration of the cavity with abdominal fat.
- The posterior belly of the digastric muscle is sutured to the sternocleidomastoid muscle.
- Suturing of these two muscles to the temporalis muscle and to the retroauricular soft tissue.
- Watertight closure of the subcutaneous and cutaneous tissue.
- Compression dressing.
- Transposition of the temporalis muscle is never used, to avoid aesthetic problems.
- No drain is used.