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The modified retrosigmoid approach: a how I do it

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Abstract

Background The traditional retrosigmoid (RS) approach provides limited exposure of the inferior compartment of the CPA, while radical skull base approaches are demanding and associated with significant morbidity.

Methods This study outlines the relevant surgical anatomy and the different surgical steps of a modified retrosigmoid (MRS) approach.

Results The MRS provides enhanced exposure of the CPA and deep vascular structures resulting from a modified RS craniotomy and limited exposure of the sigmoid sinus.

Conclusion In selected posterior fossa lesions, this cisternal approach is a straightforward corridor that can be routinely performed as a safe alternative to radical cranial base approaches.

Keywords Lower cranial nerves tumor · Modified retrosigmoid approach · Proximal PICA aneurysm · Skull base surgery

Abbreviations

CN	Cranial nerve
CSF	Cerebrospinal fluid
MRS	Modified retrosigmoid approach
PICA	Postero-inferior cerebellar artery
RS	Retrosigmoid approach
SS	Sigmoid sinus
TS	Transverse sinus

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Relevant surgical anatomy

The surgical management of posterior fossa and brainstem vascular or tissular lesions is challenging. The traditional retrosigmoid (RS) approach provides limited exposure, while radical skull base approaches (transpetrosal approaches, far-lateral approach) are demanding and associated with a high morbidity rate. The modified retrosigmoid (MRS) approach consists in a modified RS craniotomy and a limited exposure of the sigmoid sinus (SS).

The MRS exposes the fourth segment of the ipsilateral vertebral artery (VA) (intra-dural segment), from the lower lateral surface of the medulla, at the level of the dentate ligament, to the vertebrobasilar junction where it joins the contralateral VA. The MRS gives access to the first and second segments (anterior and lateral medullary segments) of the PICA [5], from its origin to the rootlets of the lower CNs. The CNs are exposed from the trigeminal to the hypoglossal nerve (Fig. 1a).

Most of the distal VA, vertebrobasilar junction, and proximal PICA vascular lesions are accessed through surgical anatomical triangles as described by Lawton [4], which are the natural working window for the MRS. The vagoaccessory triangle is defined superiorly by the vagus nerve, the accessory nerve laterally, and the medulla medially. It is sub-divided into two smaller triangles by the hypoglossal nerve: the supra- (the area between CNs X, XI, and XII) and infra- (between CNs XI, XII and the medulla) hypoglossal triangles (Fig. 1b).

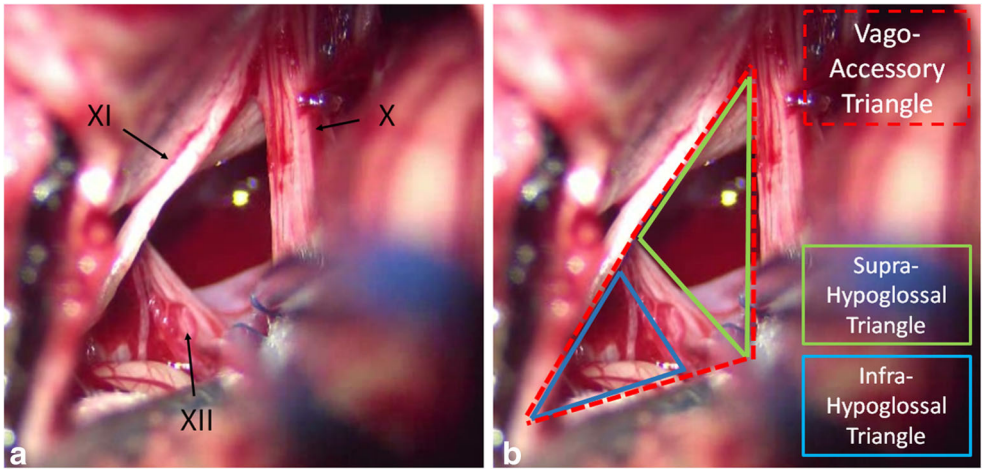

Fig. 1 Surgical anatomical triangles exposed by the modified retrosigmoid approach. **a** The vagoaccessory triangle is defined superiorly by the vagus nerve, the accessory nerve laterally, and the medulla medially. **b** The vagoaccessory triangle is subdivided into two smaller triangles by the hypoglossal nerve: the supra- (the area between CNs X, XI, and XII) and infra- (between CNs XI, XII and the medulla) hypoglossal triangles

Description of the technique

Patient positioning and preparation: (Fig. 2a)

The patient is installed in a lateral position toward the opposite side; a bolster is placed under the thorax. The head is placed in a horseshoe headrest, in a neutral position and slightly flexed such as that the ipsilateral mastoid tip is the highest point in the operative field. The ipsilateral shoulder is taped down to increase the working space. The surgeon stands behind the head and the pinna.

Soft tissues dissection: (Fig. 2b)

A straight 8-cm skin incision is carried out, starting 1 cm above the pinna and ending up at the level of the mastoid tip inferiorly. This skin incision spans the galea and the underlying pericranium. The muscles and deep fascia are elevated from the bone with a monopolar section and retracted anteriorly. The sternocleidomastoid muscle is detached from the mastoid and mobilized downward. The outer surface of the mastoid process anteriorly and the squamous part of the occipital bone, from the asterion superiorly to the digastric groove and foramen magnum inferiorly, are fully exposed.

Craniotomy—bone flap: (Fig. 2d)

One burr hole is performed under and below the asterion. This burr hole exposes the dura of the SS. The dura is detached from the inner table of the suboccipital bone, starting from the sinus side toward the center in order to avoid tearing of the sinus. A 3.5- to 4-cm bone flap is cut. The shape of the flap is straight laterally and curved medially.

The surgeon is then equipped with a 6-mm cutting burr and gradually shaves the mastoid air cells covering the posterior third over a 3-cm length of the SS, under copious irrigation. The drill is held like a pen and oriented tangentially to the structures that must be shaved. It is strongly recommended to leave a thin shell of compact bone over the sinuses to avoid any tear. This shell will be subsequently elevated with a sharp dissector.

Intra-dural step

A C-shaped dural opening based on the posterior edge of the SS is performed. Dural tenting sutures are placed adjacent to the SS, and the dural flap is reflected anteriorly using a clamp to provide dynamic improvement of the surgical window. Cottonoid paddles are placed over the surface of the cerebellum, and the cerebellomedullary cistern is opened to obtain CSF depletion, minimizing the amount of retraction necessary for adequate exposure. The operative window is focused on the lower CNs.

Closure

The closure is done by reapproaching the dura using a 5/0 prolen thread. At this point, the dura cannot be easily closed watertightly. Thus, the usual way is to plug the defect and the mastoid cavity using fat. This step requires an additional skin incision. We routinely use stripes of sub-occipital muscle with fibrin glue. The mastoid air cells are waxed to prevent CSF leak. The bone flap is repositioned and fixed with titanium plates. The bony defects are covered by application of bone powder.

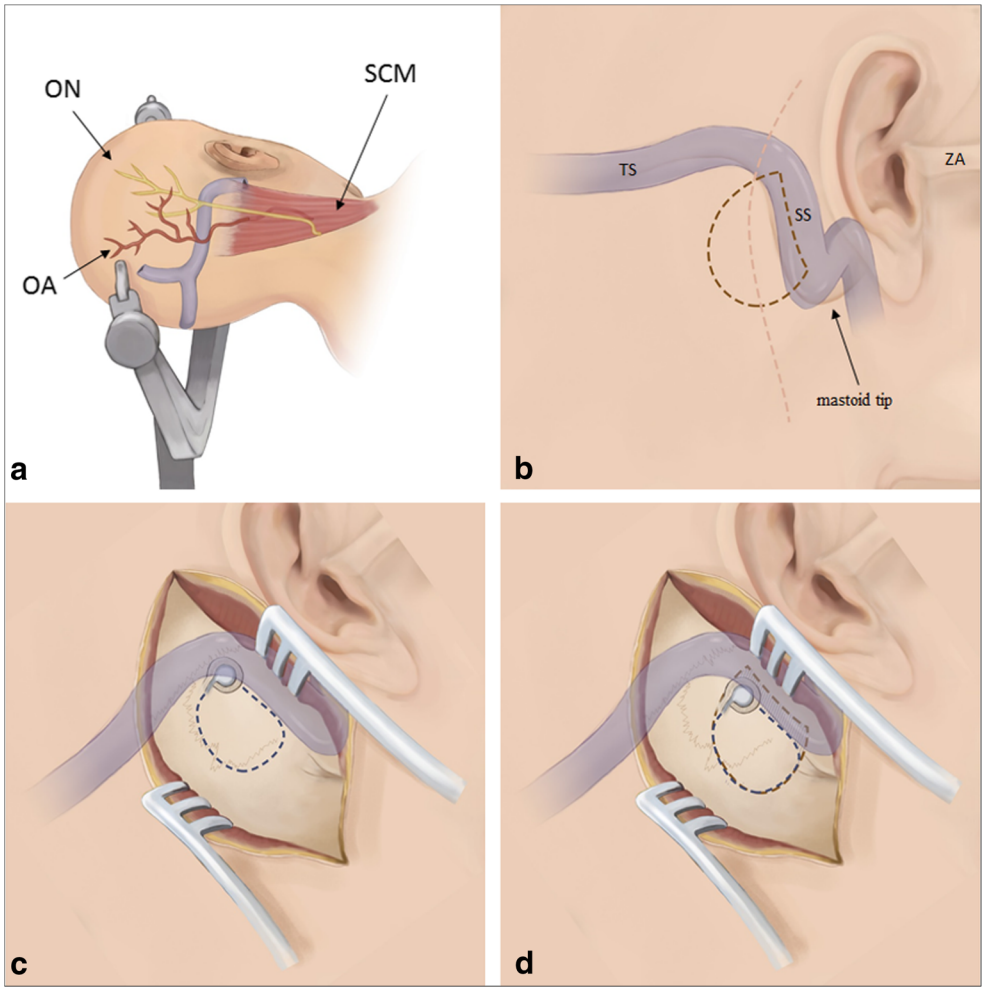

Fig. 2 Schematic stepwise representation of the modified retrosigmoid approach. **a** Head positioning. The patient is installed in a lateral position toward the opposite side. The ipsilateral mastoid tip is the highest point in the operative field. The ipsilateral shoulder is taped down to increase the working space. Incision (yellow dotted curved line—Fig. 2b) encounters the occipital artery (OA) and should avoid trajectory of the occipital nerve (ON). SCM sternocleidomastoid muscle. **b** Surface landmarks of the skin incision (yellow dotted curved line) and craniotomy (purple dotted line). Two main landmarks are used to define the lateral sinus and its transverse/sigmoid junction. The superior nuchal line, defined as a line connecting the inion with the zygomatic root, is located at the level of the distal transverse sinus. The mastoid groove overlies the posterior part of the sigmoid sinus. ZA zygomatic arch, SS sigmoid sinus, TS transverse sinus. **c** Standard retrosigmoid craniotomy. The initial "strategic" burr hole is located just inferior and medial to the junction of transverse-sigmoid venous sinuses. **d** Modified retrosigmoid craniotomy. The burr hole exposes the dura of the SS. A 3.5- to 4-cm bone flap is cut. The shape of the flap is straight laterally and curved medially. The craniotomy should be enlarged laterally by removing the mastoid air cells covering the posterior third margin of the sigmoid sinus

Illustrative case: (see video and Figs. 3, 4, and 5)

Indications: [2, 3]

- Distal VA, vertebrobasilar junction, and proximal PICA aneurysms (1st and 2nd segments)
- Extra-axial CPA lesions of the lower CNs (Fig. 5)
- Intra-axial lesions of the brainstem, cerebellar peduncle, and cerebellar hemisphere that present a surface to the subarachnoid space

Limitations

- Distal PICA aneurysms (3rd to 5th segments)
- Lesions located upper or medially to CN V. Jugular foramen tumors extending intra- and extracranially [1]
- Limited potential of dura resection (difficult to achieve a Simpson I resection of broad-based meningiomas)

How to avoid complications

- The surgeon carefully checks the angioMR to assess the course of the SS and jugular bulb and to exclude a

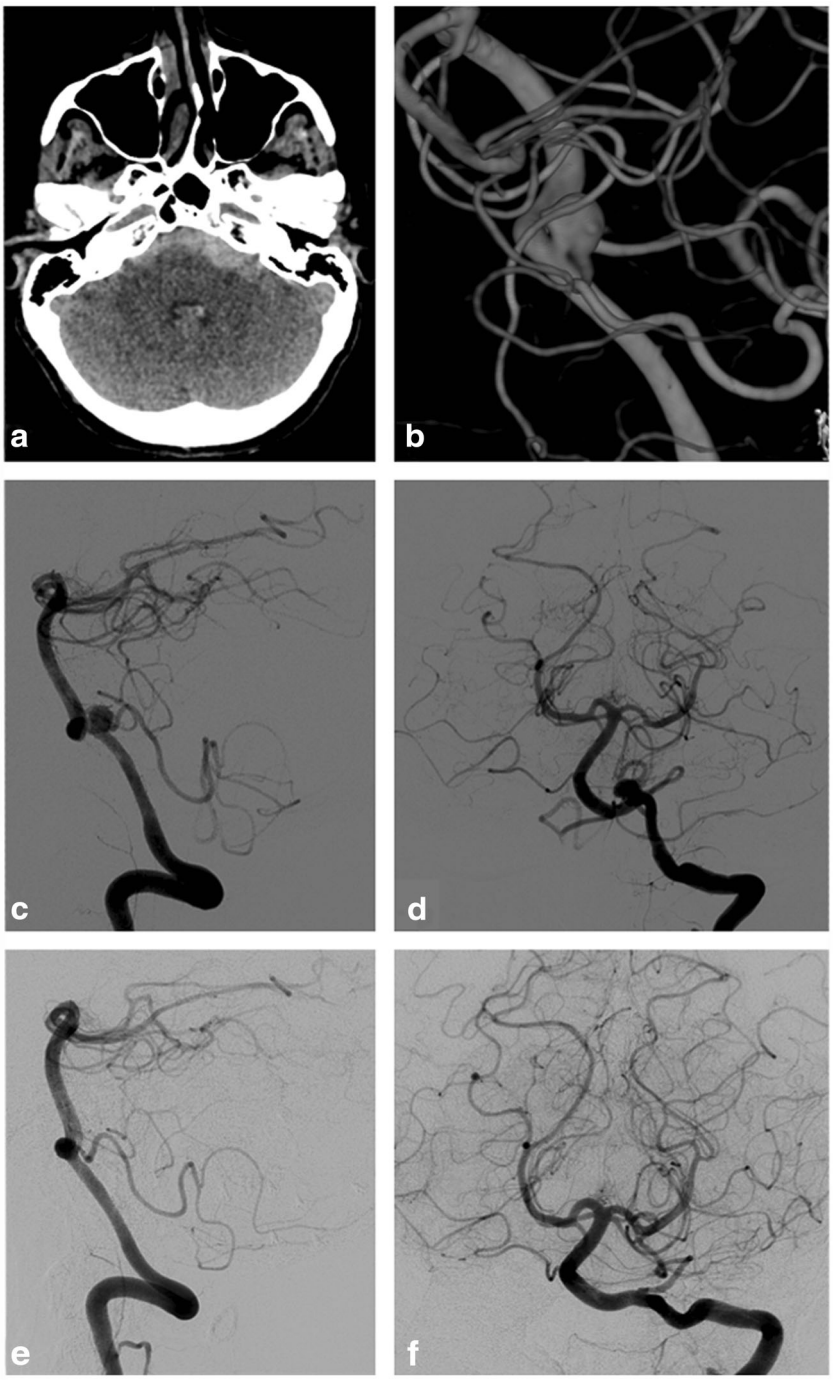

Fig. 3 Illustrative case: vertebral artery—PICA junction aneurysm. Imaging. A 57-year-old woman presented with sudden and severe meningeal syndrome with confusion, WFNS 2. **a** The preoperative axial CT scan revealed a Fisher 4 SAH predominant in the posterior fossa cisterns and fourth ventricule. **b**, **c**, and **d** The CT and angiography showed a 5.5-mm broad-based left vertebral aneurysm. The PICA origin arose from the base of the aneurysm. No attempt of endovascular treatment was made because of the high risk to occlude the PICA. **e** and **f** Postoperative angiography demonstrated complete occlusion of the aneurysm and a patent parent vessel. The patient presented postoperative transient lower cranial nerves dysfunction and transient diplopia due to the ipsilateral VI nerve manipulation. The patient was discharged home 16 days after surgery, and the neurological deficits completely resolved at 6-month follow-up

potential contralateral sinus occlusion (contraindication). The CT bone window of the petrous bone confirms the amount of pneumatisation of the mastoid air cells.

- Intra-operative venous congestion may occur because of sinus manipulation, in which case, it is necessary to temporarily relax the dural tenting sutures.
- Hemorrhagic injuries of the SS or TS are rare. The vertical portion of the sinus is fragile. The injury may happen during craniotomy, while drilling the mastoid process or during dura opening. Dangers are blood loss, air embolism, and sinus thrombosis. Direct suture is generally difficult to achieve. There is a need to avoid permanent occlusion of the sinus. We propose to cover the hole with a patch of muscle and fibrin glue. Another technique is to rotate the flap of dura that will be stitched and maintained against the sinus with tack-up sutures on the mastoid.

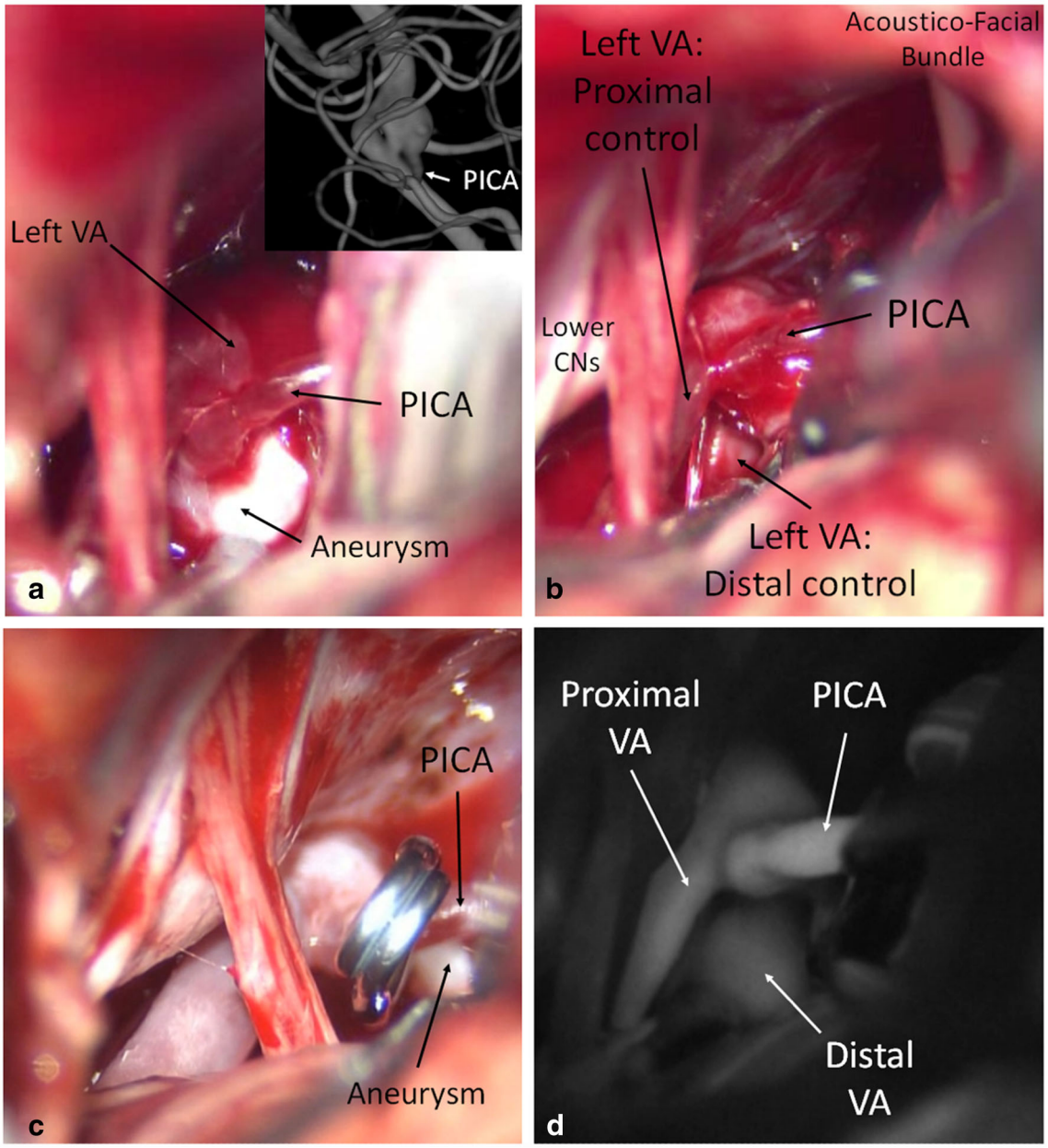

Fig. 4 Illustrative case: vertebral artery—PICA junction aneurysm. Operative view. **a** The PICA clearly arose from the base of the aneurysm. Proximal and distal control on the VA are obtained before dissecting the dome of the aneurysm. **b** and **c** The aneurysm was clipped with a straight fenestrated 9-mm clip that closed the aneurysm while encircling the PICA origin. **d** The intra-operative ICG videoangiography confirmed patency of the parent vessels and no further filling of the aneurysm

Specific perioperative considerations

- The patient is routinely managed in the ICU during the first 24 h. The oral administration of water and food will be started gradually after careful checking of the lower cranial nerve function. If any doubt about potential dysfunction of lower CNs, an endoscopic examination of the vocal cords and swallowing is asked to the ENT surgeon before feeding the patient back. A systematic non-enhanced CT is performed within 24 h.
- Early postoperative Valsalva maneuvers are prohibited to limit the risk of CSF leak.

Specific information to give to the patient about surgery and potential risks

- Disorders affecting the lower CNs (dysphonia, dysphagia)

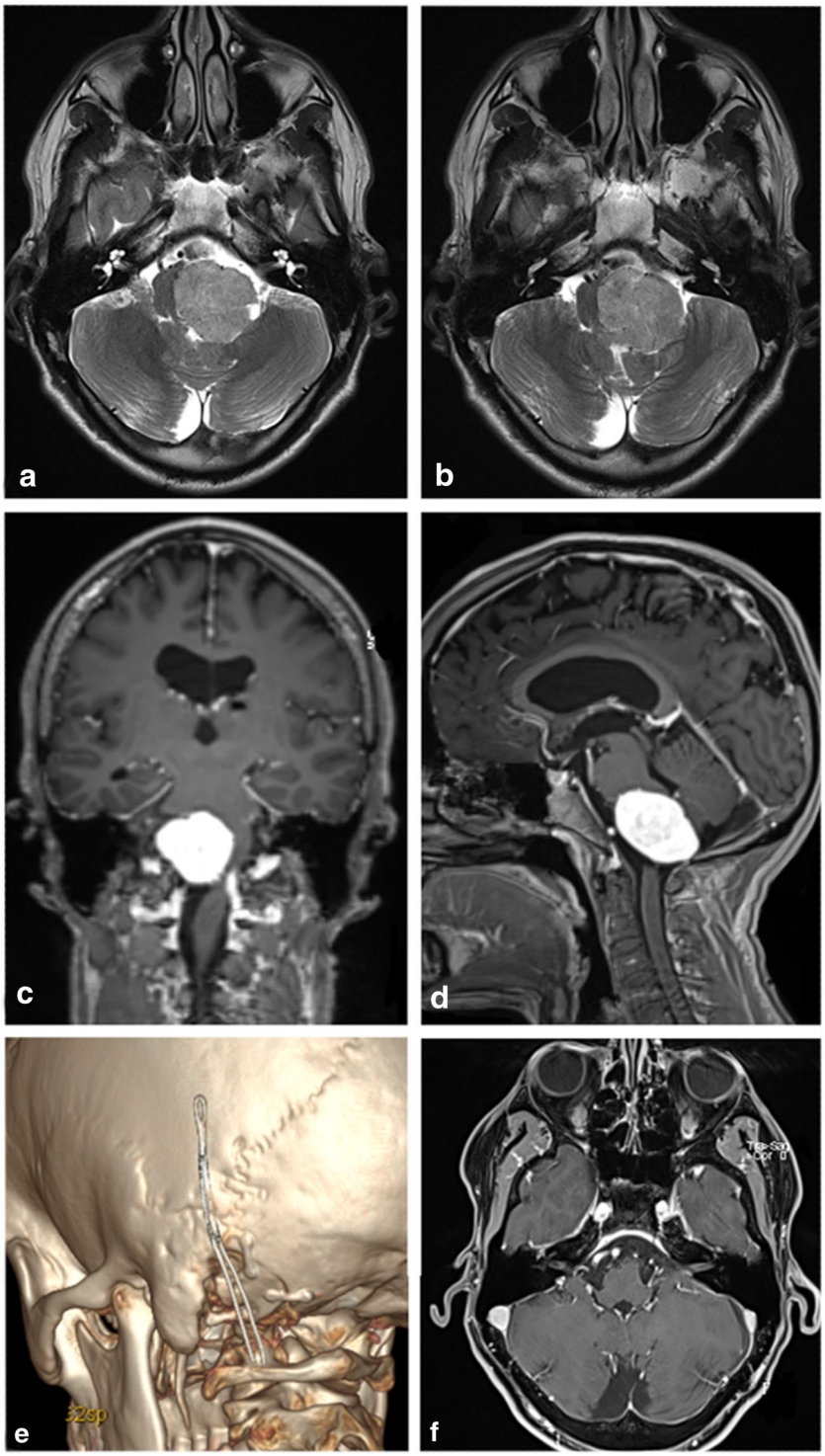

Fig. 5 Lower cranial nerve tumor operated via a modified retrosigmoid approach. **a**, **b**, **c**, and **d** Preoperative axial T2 and sagittal and coronal contrast-enhanced T1-weighted MRI showing a 37/45/30-mm left extra-axial CPA tumor in a 36-year-old man. He presented with a balance instability, nystagmus, and lower cranial nerve disturbances. He was operated via an MRS approach. **e** and **f** The postoperative 3D CT-scan shows the MRS craniotomy. The postoperative MR images confirmed complete resection of the lesion. The diagnosis of hemangiopericytoma was histologically confirmed

- CN VI (diplopia), acoustic-facial bundle (facial weakness, hearing loss)
- CSF leaks: prevention and treatment
- Postoperative hematoma and consequences

Relevant points

- Preoperative workup (location, nature, and extension of the lesion)

- Lateral position, mastoid tip at the zenith, ipsilateral shoulder taped down
- "Key hole" under and below the asterion
- 4 × 4-cm-modified retrosigmoid bone flap
- Exposure of the SS
- Tacked-up sutures adjacent to the SS to optimize exposure
- Open the cerebellomedullary cistern to withdraw CSF and get enough relaxation of the brain
- Meticulous intra-dural hemostasis
- Watertight closure and obturation of the mastoid air cells

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest. The manuscript has not been previously published in whole or in part or submitted elsewhere for review.

Patient consent The patient has consented to the submission of this How I Do It for submission to the journal.

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