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HOW I DO IT - TUMOR - MENINGIOMA

How I do it: anterior interhemispheric approach to tuberculum sellae meningiomas

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Abstract

Background Tuberculum sellae meningiomas are deep-seated tumors difficult to access, located in close relation with important neurovascular structures. While the transsphenoidal approach is linked to specific complications, the different reported transcranial approaches are associated with advantages and drawbacks due to the respective angle of attack, with some areas adequately exposed and others partially hidden.

Method We report the technical aspects of the anterior interhemispheric approach we practice.

Conclusion This approach has the advantage of providing full control over all the vasculo-nervous structures involved and of allowing access to the medial aspect of both optic canals tangentially to the dorsum sellae.

Keywords Anterior interhemispheric approach—meningioma · Skull base · Surgical technique—tuberculum sellae

Abbreviations

ACA	anterior cerebral artery
AIH	anterior interhemispheric
CSF	cerebrospinal fluid
FS	frontal sinus
ICA	internal carotid artery
OC	optic canal
ON	optic nerve
TS	tuberculum sellae
TSM	tuberculum sellae meningioma

Tuberculum sellae meningiomas (TSMs) can be approached by different transcranial approaches providing different attack angles or via a transnasal-transsphenoidal endoscopic route [1–10]. Our goal is to describe the anterior interhemispheric (AIH) approach practiced by the senior author (MB).

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Relevant surgical anatomy

TSMs arise from the tuberculum sellae (TS), limbus sphenoidale, or chiasmatic sulcus dura, more often laterally [5]. TSMs grow around the TS and extent anteriorly along the planum sphenoidale, posteroinferiorly along the dorsum and diaphragma sellae, and medially inside the optic canal (OC) on one or both sides. Visual disturbances are the most common symptom due to optic apparatus distortion or extension inside the OC(s) [5].

TSMs develop in close relation with the anterior circulation arteries which can be either displaced, completely circumscribed, or even embedded within the lesion. Small perforating branches are extremely important to respect, feeding the optic nerves (ONs) and chiasm, the pituitary gland, tuber cinereum, and mamillary bodies.

Description of the technique (Figs. 1, 2, 3)

The patient is placed supine, thorax 30°-elevated with the head 10°-extended.

Neuronavigation is a valuable tool; the planning includes the following:

(a) Tumor delineation
(b) A first trajectory targeting the tumor's anterior aspect on the midline, with a parasagittal entry point

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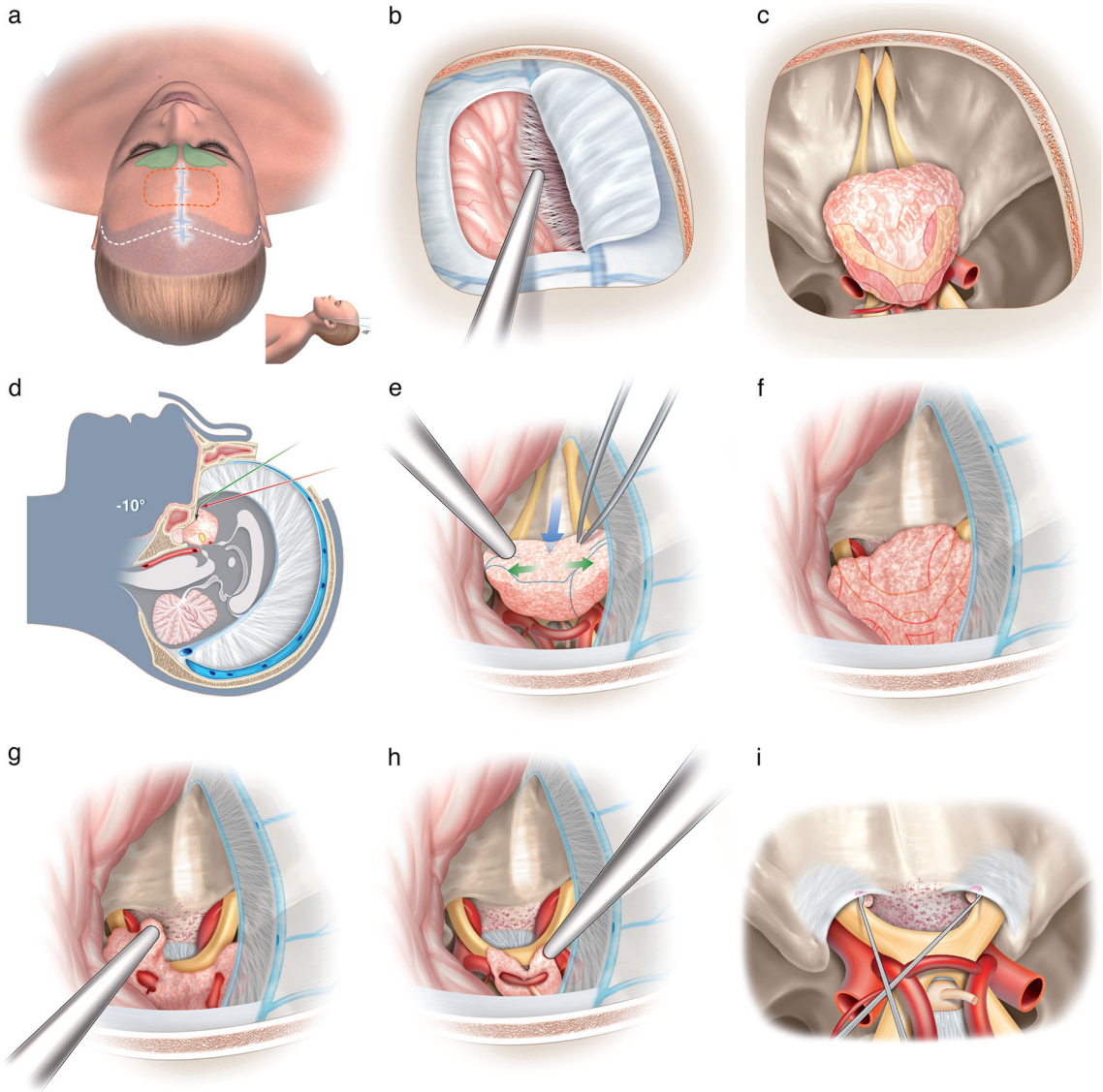
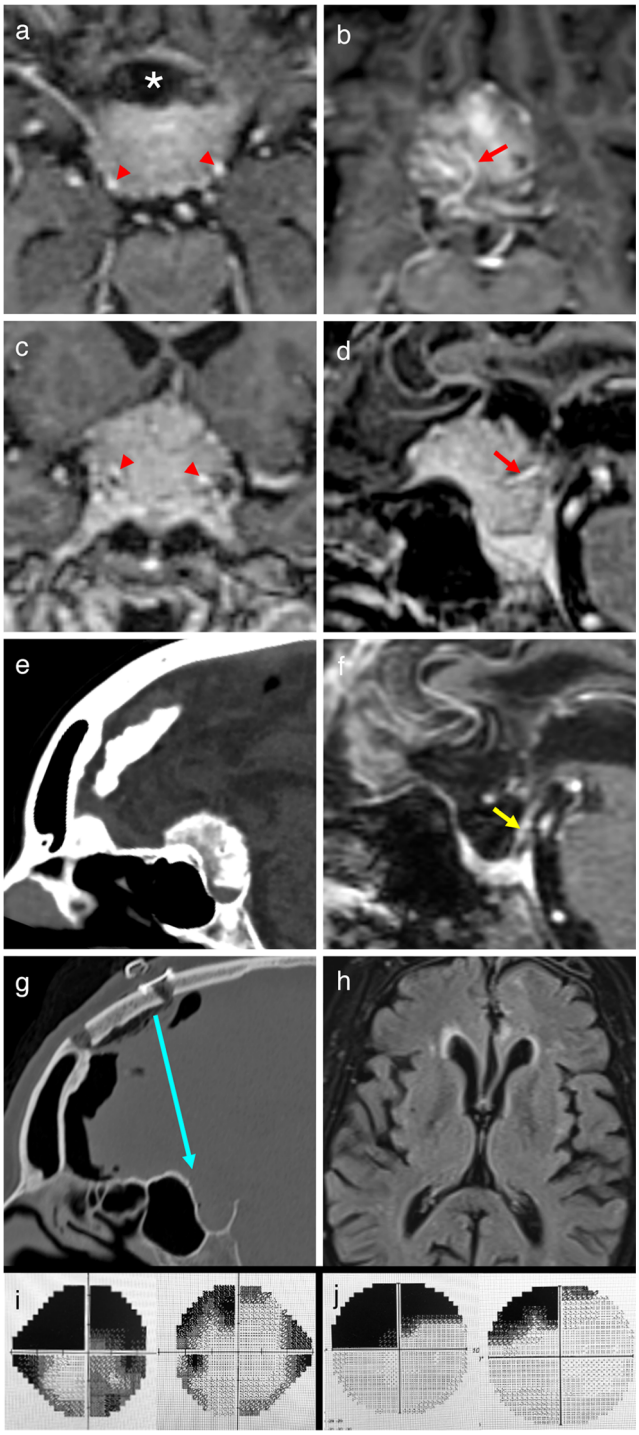


Fig. 1 Illustration of the technique. **a** Patient positioning and skin incision in regard to craniotomy and frontal sinus location. **b** Unilateral dural opening at distance from the bridging veins; the dura remains pediculated on the superior longitudinal sinus. An anterior interhemispheric approach is carried out. **c** Superior view on the tuberculum sellae meningioma. **d** Surgery starts by reaching the anterior pole of the tumor according to the red trajectory. Subsequently, the microscope is verticalized and the green trajectory is followed to remove the anterior pole of the tumor on the midline towards the tuberculum sellae. **e** When reaching the tuberculum sellae, the resection is pursued cautiously bilaterally in a mediolateral direction towards the optic nerves. **f** The less compressed optic nerve is decompressed first. **g** When the vessels are completely embedded within the tumor, obtaining proximal and distal vascular control is helpful. With the progression of the tumor resection, the most compressed optic nerve and the chiasm become exposed. **h** The anterior cerebral artery is finally dissected. **i** When a tumor extends inside the optic canal, the superior view provides a full bilateral visual control for removing this extension and completely decompress the optic nerves

(c) A second trajectory reaching the tumor's posterior aspect on the midline
(d) Anterior circulation vessels

A limited bi-coronal skin incision is performed behind the hairline and the skin is retracted anteriorly. A midline anterior burr hole is performed above the superior longitudinal sinus, 3–5 mm posterior to the frontal sinus (FS) to avoid any sinus disruption. A second midline burr-hole is performed 40 mm posteriorly. A vein-free space greater than 15 mm must be obtained in the craniotomy center. Despite the intradural approach is mostly performed unilaterally, the craniotomy is performed bilaterally to allow strategy changes, insertion of a contralateral retractor (if needed), and obtain a second angle of attack. Vein location requires some adaptation in craniotomy size, dural opening, and interhemispheric trajectory.

Under a microscope, a C- or H-shaped 15–20 mm-wide unilateral dural opening is performed, on the side contralateral



◀ **Fig. 2** Case of a 67-year-old woman suffering from lowered visual acuity and visual field defect due to a calcified tuberculum sellae meningioma. **a**-**e** Preoperative images. **a**-**d** MRI axial (**a**, **b**), coronal (**c**), and sagital (**d**) images showing the internal carotid arteries (arrowheads) and anterior cerebral arteries completely embedded inside the meningioma (arrows) whose anterior aspect is calcified (*). **e** Sagital CT scan showing the calcified meningioma and the size of the frontal sinus. **f**-**h** Postoperative images. **f** Sagital MRI confirms complete tumor resection. The pituitary stalk is visible (yellow arrow). The patient has a normal postoperative endocrinological function. **g** CT scan showing the location of the bone flap, close to the frontal sinus but without transgression. Through the posterior aspect of the bone flap, the superior surgical view allows an adequate view behind the tuberculum sellae, along the dorsum sellae (blue arrow). **h** FLAIR image confirming an atraumatic interhemispheric approach. **i**-**j** Visual fields, preoperative (**i**) and postoperative (**j**) control confirming improvement

to the more lateral tumor extension or OC invasion to limit ipsilateral hemisphere retraction and obtain a better view. In the case of symmetric tumor development and bilateral OC extension, a right-sided approach is favored.

The AIH approach starts by following the first neuronavigation trajectory targeting the tumor anterior aspect on the midline, with the microscope angled to obtain a posteroanterior view. The approach is performed straight along the falx. Two rolled cotton pads placed between the falx and the frontal lobe can maintain the view open; blade retraction is almost never necessary. Afterwards, the AIH fissure is opened, keeping the arachnoid plane intact. Quite often, frontal lobes interdigitations make such opening technically demanding. When the tumor anterior aspect is reached, the dissection is extended posteriorly above the tumor without requiring sustained brain retraction.

Tumor resection starts on its midline anterior pole, by following the second neuronavigation trajectory. Using suction/bipolar coagulation or ultrasonic aspirator, the tumor is resected medially towards the TS. Then, the tumor's central core is partially debulked. The resection progresses subsequently along the tumor base at the TS level from the midline towards both OCs, without applying lateral forces on ONs. The debulking is interrupted when ONs become visible. ONs identification provides important anatomical landmarks to make the resection safer. The debulking is then completed extensively in all directions inside the tumor to render the remnant mobile, allowing an easier and safer peripheral arachnoidal plane dissection. Sequentially, the peripheral tumor remnant is pushed centripetally inside the empty cavity allowing a progressive atraumatic separation from the frontal lobes, olfactory nerves, and ONs.

The less compressed ON is dissected first. On the medial ON side, the ICA and ophthalmic artery become visible. In some cases, the tumor extending laterally to the ON requires to work consecutively on both ON sides with a blade placed on the falx or gently along the frontal lobe to enlarge the view.

The ICA with its branches and the anterior cerebral arteries (ACAs) must be dissected carefully. The optic apparatus vascularization must be cautiously respected. Finally, the pituitary stalk and vasculature appear.

The view is better on the contralateral OC medial side. The view on the ipsilateral OC is adequate but more tangential than perpendicular. Tumor extension inside the OCs can be resected using small angled curettes, while taking care of carefully dissecting the ophthalmic arteries. Falciform ligament section is possible but not necessary since ONs are already decompressed when becoming visible.

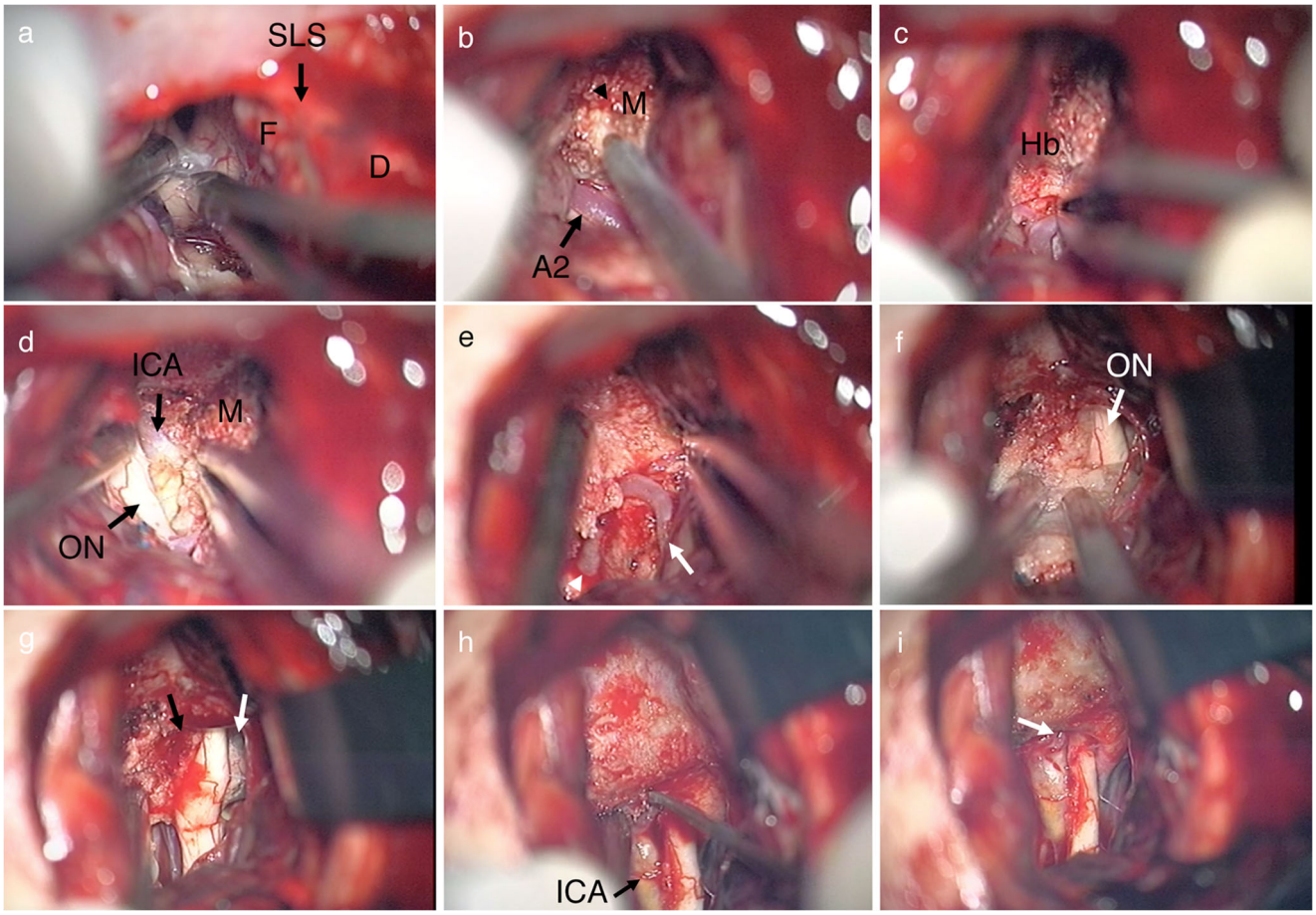


Fig. 3 Intraoperative images of the case illustrated in Fig. 2. **a** Interhemispheric dissection through a left approach. D: pediculated dura mater. F: falx, SLS: superior longitudinal sinus. **b** The anterior aspect of the meningioma (M) is reached on the midline (arrowhead) and debulking is started on the midline using an ultrasonic aspirator. A2: A2 segment of the anterior cerebral artery. **c** The left Heubner artery (Hb) is carefully separated. The anterior communicating artery complex is completely embedded within the meningioma. **d** The left optic nerve (ON) is decompressed; the internal carotid artery becomes visible (ICA). **e** The anterior cerebral artery completely embedded inside the meningioma has been dissected safely with a proximal (arrowhead) and distal (arrow) vascular control. **f** Progression of tumor debulking allows to identify the right optic nerve. Note a blade placed on the falx. **g** The meningioma extends in the right optic canal (black arrow), passes below the optic nerve (between the optic nerve and the ICA) which is severely compressed, and extends laterally to the nerve (white arrow). **h** The tumoral component passing below the optic nerve has been resected and the right ICA is visible as preserved microvessels (arrow). At the final stage after resection, the tumor extension inside the optic canal is removed with full visual control through this superior view. **i** Final view after complete tumor resection. Abbreviations: A2: A2 segment of the anterior cerebral artery, D: dura mater, F: falx, Hb: Heubner recurrent artery, ICA: internal carotid artery, M: meningioma, ON: optic nerve, SLS: superior longitudinal sinus

In the case of complete vessel embedding, especially the ACAs branches, the debulking must be started at distance from the hazardous areas before focusing on the sensitive structures. Neuronavigation can be helpful by delineating dangerous structures. The vessel must be exposed first in a normal area and proximal and distal vascular controls must be obtained as early as possible. Distal exposure is a unique advantage of the AIH and is extremely valuable, allowing a safer distal-to-proximal dissection.

In the end, the dural base is coagulated or resected. The dura is closed as watertight as possible, without any bridging vein damage. Bone flap is secured and a two-layer closure made without drainage.

Indications

All TSMs could be resected by a unilateral AIH approach.

The AIH approach owns several advantages:

1- An almost symmetrical superior view on both OCs, ONs, and optic chiasm is provided. Importantly, the ONs do not impede the view of the tumor, contrarily to lateral approaches exposing first the ipsilateral ON hiding to a variable extent the meningioma.
2- A tangential view along the dorsum and diaphragm sellae allows a direct exposure of the posteroinferior extension.
3- Full proximal and distal control over the vessels is possible.

Limitations

1- Prefix chiasm could limit the access.
2- The AIH approach is technically demanding and requires a cautious interhemispheric fissure opening.
3- Bridging veins can limit the approach and must be respected.

How to avoid complications

1. Anticipate FS and bridging veins location
2. Anticipate anterior circulation arteries location
3. Perform an atraumatic AIH fissure dissection
4. Perform as much as possible a retractorless surgery

Specific perioperative considerations

Preoperatively, contrast-enhanced 3D T1-weighted MR images allow to circumscribe the lesion, detect asymmetry in tumor development, evaluate the degree of OC(s) invasion, and determine the ONs and chiasm displacement. TOF and T2-weighted images inform also about vessel location. A possible dissection plane with the adjacent cortex can be appreciated on T2 sequences. CT scan is useful to detect cranial base hyperostosis and calcified areas inside the tumor. The surgical approach is based on a CT scan to delineate the FS and on MRI to anticipate bridging veins location. Complete ophthalmological examination identifies visual acuity and visual field deficits. Endocrinological testing completes the workup.

Postoperatively, an early CT scan allows to exclude any complication. Endocrinological function is closely monitored. MRI at 2 months confirms the resection degree. Complete ophthalmological examination evaluates the resection benefit.

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

The patient could face potential specific complications

1. Olfactory dysfunction with anosmia
2. Visual worsening
3. Pituitary dysfunction requiring hormonal replacement therapy
4. CSF leakage
5. Venous infarction
6. Stroke

Conclusions

The AIH approach provides several significant advantages compared to trans-sphenoidal and other transcranial approaches to resect TSMs, with few drawbacks.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00701-020-04653-7.

Compliance with ethical standards

Conflict of interest All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge, or beliefs) in the subject matter or materials discussed in this manuscript.

Informed patient consent The authors received consent of the patients.

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Key points 1. Select the approach side depending on bridging veins location and opposite to the most lateral tumor extension.

2. Use neuronavigation to locate anatomical structures.

3. Target first the tumor anterior aspect on the midline.

4. Debulk the tumor first on the midline to the TS.

5. Resect the tumor gently from the midline in ONs direction with an ultrasonic aspirator without lateral stretching.

6. Debulk the tumor largely to make the remnant mobile before making a centripetally peripheral dissection.

7. Obtain early proximal and distal vascular control.

8. Respect all microvessels.

9. Remove any tumor extension inside the OC(s).

10. Remove as extensively as possible the pathological dura mater.