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HOW I DO IT - NEUROSURGICAL TECHNIQUES

The supraorbital keyhole approach: how I do it

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Abstract

Background Improvements in image guidance, endoscopy, and instruments, have significantly advanced "keyhole" neurosurgery. We describe the concept and technique of the supraorbital keyhole approach.

Methods The supraorbital keyhole approach is performed through an eyebrow skin incision. Image guidance may be used to define the optimal surgical trajectory. A limited supraorbital craniotomy is fashioned. The frontal lobe is mobilized and the central skull base approached, without the need for brain retractors. Endoscopy is used to enhance visualization, and tube-shaft instruments to improve manipulation through the narrow surgical corridor.

Conclusions The supraorbital keyhole approach provides a safe method to access selected skull base lesions.

Keywords Minimally invasive neurosurgery · Neuroendoscopy · Skull base surgery · Supraorbital keyhole

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Abbreviations

CN I	Olfactory nerve
CN II	Optic nerve
CG	Crista galli
ICA	Internal carotid artery
iCT	Intraoperative computed tomography
FB	Frontal skull base
MRI	Magnetic resonance imaging
OG	Olfactory groove

Introduction

The aim of "keyhole" neurosurgery is to minimize approach-related morbidity by using tailored approaches that reduce exposure and manipulation of unaffected tissue. The supraorbital keyhole approach is one of the best examples of the keyhole concept [1–6].

Relevant surgical anatomy

Important anatomical landmarks of the frontal area include the orbital rim, the supraorbital foramen, the temporal line, the level of the frontal cranial base, the impression of the Sylvian fissure, and the zygomatic arch. Special attention should also be given to the course of the superficial neurovascular structures, particularly the supraorbital nerve. These surface markings are used to define the borders of the craniotomy and planned skin incision (Fig. 1a). Optimal placement of the craniotomy can be confirmed with the use of modern neuronavigation systems (Fig. 1b).

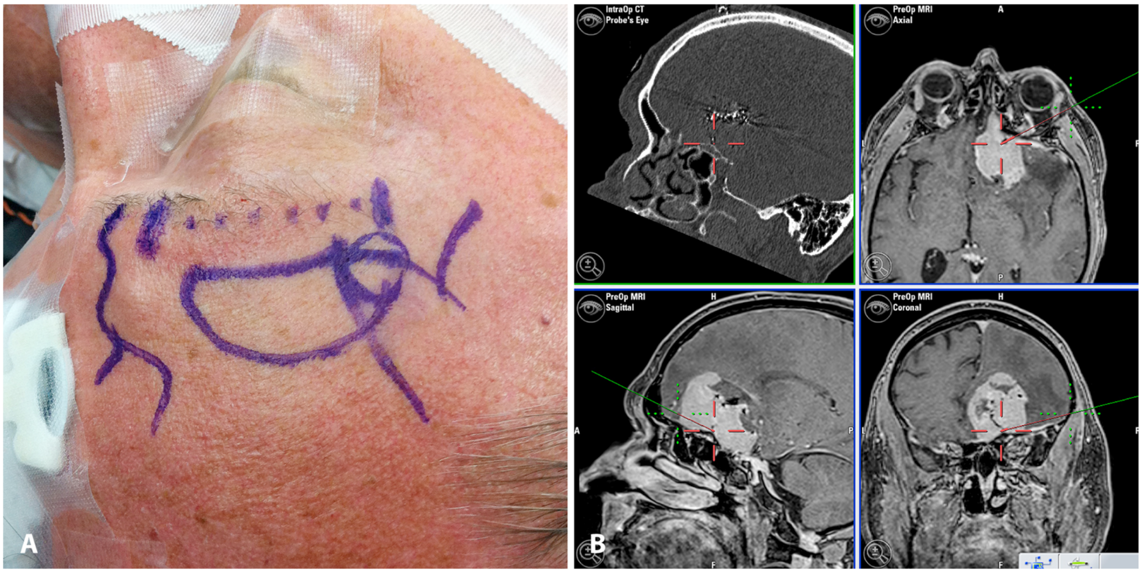

Fig. 1 **a** Key anatomical landmarks are identified, and the planned craniotomy and incision marked. **b** In this case, a neuronavigation system (BrainLAB, Feldkirchen, Germany) was used to confirm the proposed surgical trajectory

Description of the technique

Positioning and preparation of the patient

The patient is placed supine on the operating table with their head fixed in a three-pin Mayfield head holder (Codman, Massachusetts, USA).

Initially, the head is elevated above the level of the thorax to reduce intracranial pressure. The head is then retroflexed 15–30° so that gravity causes the frontal lobe to fall away from the anterior cranial fossa and allow for retractor-free intracranial dissection. The degree of rotation depends on the target region, but for exploration of the central skull base, angles of 30–60° are usually appropriate.

Incision, craniotomy, and durotomy

Step 1. The skin incision is started laterally from the supraorbital incisura within the eyebrow and carried in a lateral-to-medial direction (Fig. 2a). To achieve a cosmetically optimal result, the incision should follow the orbital rim. Note that the skin incision should not extend medially to the supraorbital nerve. After the skin incision, the subcutaneous dissection is continued in the frontal direction to achieve optimal exposure of the frontolateral supraorbital area.

Step 2. The frontal skin flap is temporarily retracted with holding sutures. The frontal muscle is then cut with a monopolar knife parallel to the orbital rim in a medial-to-lateral direction. As the temporal line is reached with the monopolar knife, the blade is turned 90° and carried along the temporal line in a basal direction to the zygomatic process of the frontal bone (Fig. 2b).

Step 3. The temporal muscle is retracted laterally with a strong hook. Using this technique, exposure and mobilization of the temporal muscle is restricted to a necessary minimum. The frontal and supraorbital muscles are retracted with sutures. A single frontobasal burr hole is then made using a high-speed drill (Fig. 2c). Optimal placement of the burr hole is lateral to the temporal line at the level of the frontal cranial base, thus avoiding penetration of the orbit.

Step 4. After minimal enlargement of the burr hole with a 2–3-mm Kerrison punch and mobilization of the dura, a straight line is cut with a high-speed craniotome parallel to the orbital rim in a lateral-to-medial direction, taking into account the lateral border of the frontal paranasal sinus (Fig. 2d). Thereafter a "C"-shaped line is cut from the burr hole to the medial border of the previously performed frontobasal line. In this way, a limited craniotomy is created with a size of approximately 25 × 15 mm.

Step 5. High-speed drilling is performed on the inner edge of the bone above the orbital rim, while protecting the dura (Fig. 2e). Small osseous extensions of the superficial orbital roof, the so-called juga cerebralia, should also be drilled extradurally to obtain optimal intradural visualization. In cases of larger intracranial lesions, the upper orbital rim may also be removed.

Step. 6. The dura is opened in a simple "C" shape and retracted in a basal direction. Note the limited exposure of the brain surface (Fig. 2f).

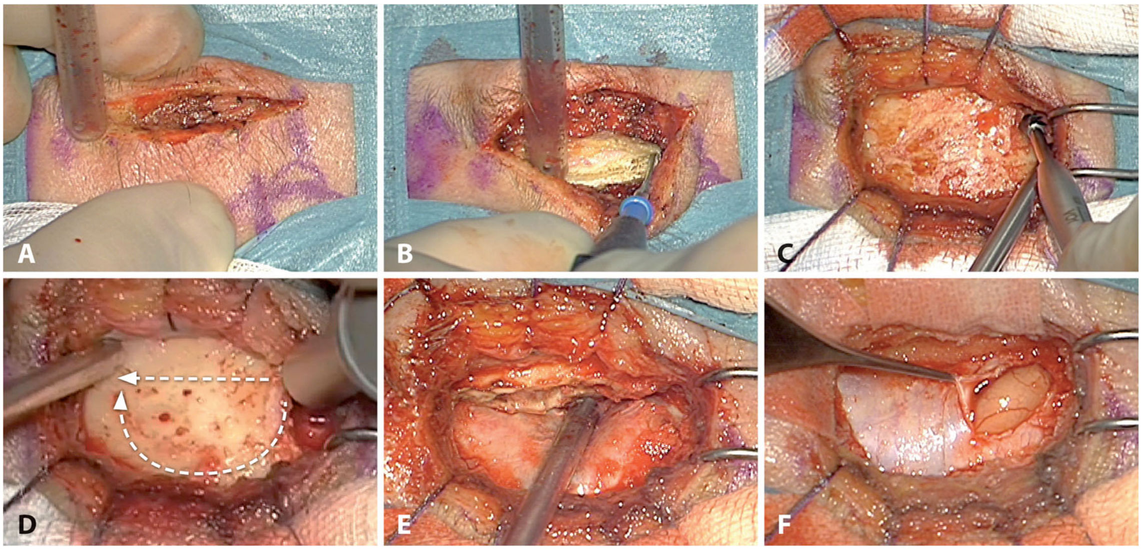

Fig. 2 Surgical steps of the supraorbital keyhole approach corresponding to the illustrative case (see text for details)

Intradural dissection: an illustrative case

Magnetic resonance imaging (MRI) demonstrated a vividly enhancing large right frontal extra-axial lesion, consistent with a meningioma (Fig. 3a). One week after successful partial embolization, the tumor was surgically approached via a right-sided supraorbital keyhole.

In this case, the tumor exerted significant mass effect and elevated intracranial pressure was observed. However, with careful mobilization of the frontal lobe, the deep subarachnoid cisterns could be reached without using an elevator (Fig. 4a). After release of CSF, the tumor was approached in a retractor-free manner.

Initially, the tumor was coagulated and detached from the frontal skull base (Fig. 4b). Thereafter, the tumor was removed piecemeal using grasping instruments, scissors, and a Cavitron Ultrasonic Surgical Aspirator (Fig. 4c). Both 0° and 30° endoscopes were intermittently used to improve visualization, allowing improved illumination and magnification, and a wider viewing angle. The intact left olfactory and both optic nerves could clearly be seen using the endoscope (Fig. 4d); and the very last parts of the tumor in the olfactory groove were removed under pure endoscopic visualization (Fig. 4e). Tube-shaft instruments were used to permit surgical manipulation through a narrow surgical corridor.

Closure

On completion of the intracranial procedure, the dura is sutured closed in a watertight fashion. The bone flap is replaced and secured with a Craniofix plate (Aesculap AG, Tuttlingen, Germany), and any craniotomy defects filled with bone cement for a pleasant cosmetic outcome. The muscles are reapproximated, and the skin closed with subcutaneous and subcuticular sutures. Tack-up sutures and wound drains are not routinely used.

Indications

The main indications for the supraorbital keyhole approach are lesions located within the suprasellar region and the surrounding central skull base. These include, but are not limited to, pituitary adenoma, suprasellar craniopharyngioma, tuberculum sella and olfactory groove meningioma, and most anterior circulation aneurysms.

Limitations

The supraorbital keyhole approach is technically challenging, restricting its use to selected cases. Improved training and technological advances may, to an extent, mitigate these technical limitations (Table 1).

How to avoid complications

Inadequate preoperative planning and poor patient positioning can impair subsequent exposure. Lesions close to the frontal skull base require retroflexion of 15°, while those situated more cranially require retroflexion of about 30°. Similarly, ipsilateral lesions require rotation of 10–15°, while those located in the olfactory groove require rotation of 45–60°.

A skin incision carried too medially can lead to postoperative numbness. The patient's surface anatomy should be carefully marked, including the supraorbital foramen, to reduce the risk of injury to supraorbital nerve.

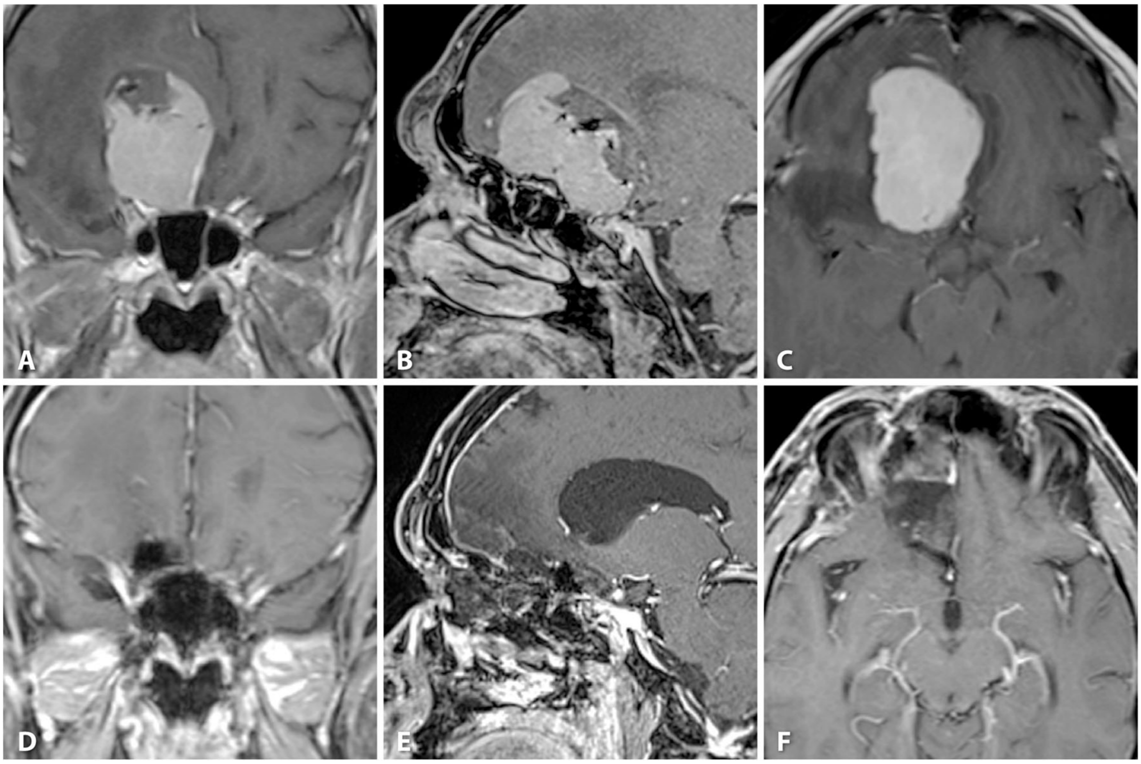

Fig. 3 **a**–**c** T1-weighted triplanar MRI with contrast medium demonstrating a large right frontobasal and olfactory groove meningioma. **d**–**f** MRI 3 months postoperatively demonstrating complete tumor resection

Dissection and retraction towards the supraorbital rim can result in orbital hematoma, and should be minimized. Care should be taken when fashioning the burr hole to reduce the risk of inadvertently perforating the orbit. Penetration of the frontal paranasal sinuses can lead to postoperative CSF leak. A preoperative CT scan (bone window) is used to evaluate the lateral extension of the frontal sinus to avoid penetration. Should a breach occur, repair with wax, pericranial fascia, or abdominal fat, is required.

In cases of elevated intracranial pressure, mobilization of the frontal lobe may be challenging, and release of sufficient CSF is necessary.

During closure, meticulous hemostasis and a watertight dural closure are essential to prevent postoperative

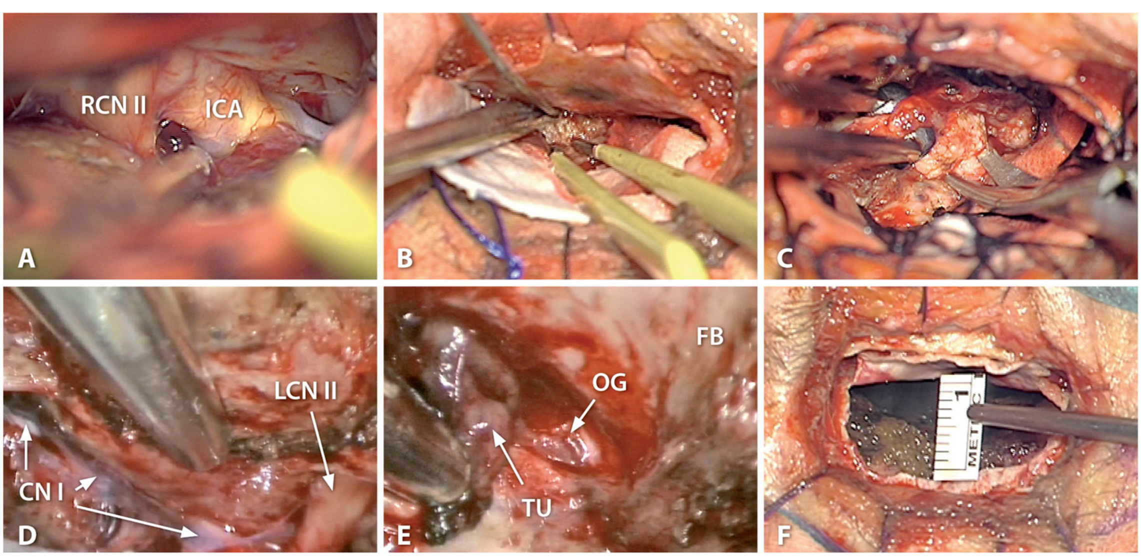

Fig. 4 Surgical steps of removal of the frontobasal meningioma without the use of a retractor. The last remnants were visualized and removed with an endoscope-assisted technique

Table 1 Limitations and solutions in keyhole neurosurgery

Limitations	Solutions
Complex anatomy, unfamiliar approach, and predefined surgical corridor	Careful preoperative planning (including a CT scan to evaluate the extent of the frontal sinus)
	Performed (or personally supervised) by the senior surgeon
	Neuronavigation and intraoperative imaging
	Neuromonitoring
Reduced field of view	Endoscope-assisted technique
Limited instrument triangulation	Tube-shaft instruments

hemorrhage and CSF leak, respectively. Inappropriate positioning and fixation of the bone flap can result in a poor cosmetic outcome. Ideally, the bone flap should be placed medially and frontally, with the Craniofix plate used for closure of the burr hole, and bone cement used for any remaining defect.

Specific perioperative considerations

Standard neurological observations are performed postoperatively. Wound drains are not placed, and subcutaneous and subcuticular sutures obviate the need for later suture removal. Patients are typically discharged 3–7 days postoperatively, and followed up in outpatient clinic at 6–12 weeks.

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

Patients should be counseled on the potential complications of surgery, depending on the nature of their pathology. Specific risks of the supraorbital approach through an eyebrow incision include frontal numbness and poor cosmesis, though these are rare [7].

Summary and key points

- Keyhole approaches offer minimal approach-related trauma; the supraorbital keyhole craniotomy through an eyebrow incision is one of the best examples of minimally invasive neurosurgery.
- Preoperative planning and image guidance may be used to precisely define the surgical trajectory.
- The head is retroflexed about 15° so that gravity causes the frontal lobe to fall away from the anterior cranial fossa and allow for retractor-free intracranial dissection.
- The skin incision should follow the orbital rim, and not extend medial to the supraorbital notch, to improve cosmesis and reduce the risk of frontal numbness.
- Placement of the burr hole lateral to the temporal line at the level of the frontal cranial base, avoids penetration of the orbit.
- Careful drilling of the inner edge of the bone above the orbital rim can considerably increase the volume of the surgical corridor.
- After opening the dura mater, the first step should be the sufficient drainage of CSF by opening the chiasmatic and carotid cisterns.
- Endoscopy and tube-shaft instruments can improve visualization and manipulation, respectively. Angled endoscopes are particularly useful in selected cases, such as low-lying olfactory groove meningiomas, in which the pathology is not entirely within the surgeon's direct line of sight.
- Neuromonitoring may further increase surgical safety.
- The bone flap should be placed medially and frontally, with the Craniofix plate used for closure of the burr hole, and remaining defects closed with bone cement for a pleasant cosmetic outcome.

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Conflicts of interest None.

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