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Technical note on the supraorbital keyhole approach: how we do it

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ABSTRACT

Background: Operating through a small eyebrow incision, the supraorbital keyhole approach has gained traction as a focused, low-morbidity route to anterior skull base pathology. This note presents our institutional technique and the practical lessons drawn from its application.

Methods: Each operative stage — patient positioning, craniotomy, dural opening, intradural work, and closure — is described in sequence. An olfactory groove meningioma serves as the worked example, illustrating how these steps translate into a clinically challenging resection.

Conclusions: Careful case selection, thorough preoperative imaging review, and adjunctive endoscopy together allow this corridor to address suprasellar and anterior skull base pathology with a favourable morbidity profile.

INTRODUCTION

Keyhole neurosurgery, as conceptualised by Perneczky and colleagues, holds that a well-sited small opening can match the exposure of much larger craniotomies for a defined target, while sparing the patient unnecessary approach-related injury [1,2]. The supraorbital route through an eyebrow incision is one of the most compelling expressions of this principle [3-6]. Its geometry is its strength: viewed under the microscope or endoscope, the operative cone expands with depth — widening exactly where anterior skull base lesions tend to sit.

Standard frontolateral and pterional approaches demand wide incisions, substantial muscle dissection, and carry well-known sequelae: temporal hollowing, jaw weakness, scalp dysaesthesia, and longer convalescence. The supraorbital keyhole sidesteps most of these costs by travelling a direct frontobasal corridor to the suprasellar space, olfactory groove, and anterior communicating complex — all without fixed brain retraction [7,8].

Contemporary neuronavigation, high-definition rigid endoscopy, and dedicated tube-shaft instruments have steadily broadened what this approach can accomplish [9]. The endoscope in particular has transformed keyhole surgery, revealing angles and recesses that

Keywords
Keyhole neurosurgery, Supraorbital craniotomy, Minimally invasive, Skull base, Endoscope-assisted surgery, Eyebrow incision

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the microscope simply cannot reach. Below, we detail our step-by-step operative method, illustrated by a case of large olfactory groove meningioma.

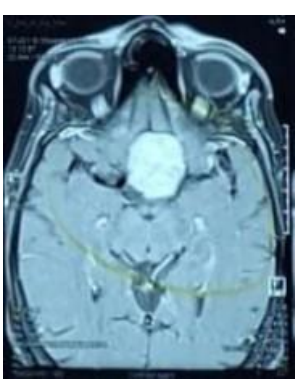
Relevant Surgical Anatomy

Sound knowledge of the frontal surface is the first requirement. The orbital rim, supraorbital notch, temporal line, and zygomatic process of the frontal bone collectively define the operative field and direct both the incision and the craniotomy footprint. The supraorbital neurovascular pedicle exits the notch roughly 2.5 cm from the midline and runs superiorly just beneath the skin; inadvertent division leaves the patient with lasting frontal numbness and must be actively prevented [10].

Immediately deep to the scalp, the frontalis covers the frontal bone and the temporalis anchors to the temporal line. Both should be disturbed as little as possible to avoid the hollowing and jaw stiffness that plague wider approaches. The frontal sinus is the most surgeon-relevant variable in planning: its lateral margin sets the safe medial boundary of the osteotomy, making bone-window CT an indispensable preoperative step in every patient [11].

Once intradural, the surgeon works within a corridor occupied by the olfactory and optic nerves, chiasm, anterior cerebral and communicating arteries, internal carotid, and pituitary stalk. The arachnoid of the suprachiasmatic and carotid cisterns is an early priority: opening it frees CSF, decompresses the frontal lobe, and replaces the need for mechanical retraction throughout the remainder of the case [12].

Craniotomy placement and operative trajectory are verified intraoperatively with frameless neuronavigation, informed by preoperative volumetric MRI for lesion localisation and corridor planning (Figure 1).



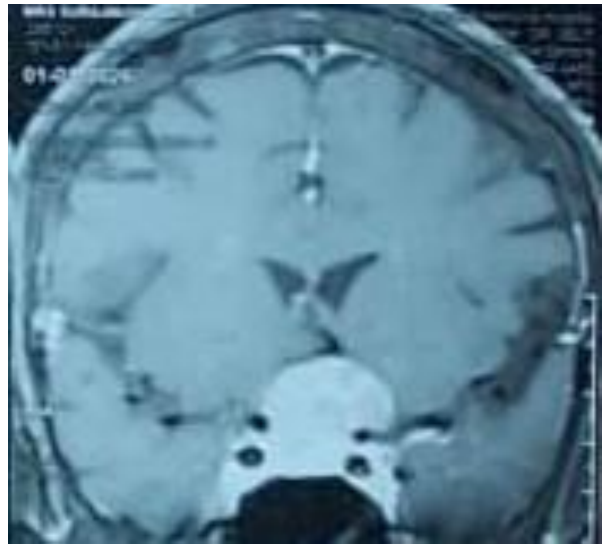


Figure 1. Preoperative MRI in axial, coronal, and sagittal planes showing the olfactory groove meningioma with marked mass effect. These sequences formed the basis for neuronavigation trajectory planning.

Description of the Technique

Positioning and Preparation of the Patient

The patient lies supine on a radiolucent table, head fixed in a three-pin Mayfield clamp (Codman, Raynham, MA, USA). Pressure points are padded, and neurophysiological monitoring leads are placed before draping when the pathology or trajectory warrants it.

The head is raised 15-20° above heart level to assist venous drainage and temper ICP. Retroflexion of 15-30° lets gravity draw the frontal lobe away from the cranial base floor, reducing the need for any retraction. Ipsilateral rotation is calibrated to pathology: 20-30° for suprasellar and midline targets, and 45-60° for olfactory groove lesions where bilateral access is needed [4]. The eyebrow, orbital rim, supraorbital notch, temporal line, and planned bone cuts are all marked on the skin before preparation. Local anaesthetic with adrenaline is infiltrated along the incision line to reduce bleeding and improve postoperative comfort.

Incision, Craniotomy, and Durotomy

Step 1: The incision begins at the lateral eyebrow margin, just medial to the temporal line, and follows the orbital rim curve medially (Figure 2a). It stops short of the supraorbital notch to spare the neurovascular pedicle and avoid frontal numbness. Dissection proceeds anteriorly in the subgaleal plane to expose the frontolateral supraorbital bone.

Step 2: The frontalis is divided with monopolar diathermy, running medial-to-lateral just above the orbital rim. At the temporal line the cut turns 90° and descends to the zygomatic process of the frontal bone (Figure 2b,c). Stay sutures hold the skin superiorly. Temporalis mobilisation is kept to the absolute minimum needed for burr-hole placement.

Step 3: A small self-retaining hook retracts the temporalis laterally. One perforator burr hole is sited lateral to the temporal line at the frontal base, keeping the drill trajectory safely above the orbit. Placement is confirmed against surface landmarks and checked with neuronavigation.

Step 4: Dura is elevated from the inner table with a Penfield dissector. The craniotome cuts from the burr hole along the frontobasal plane, parallel to the orbital rim and medial to the sinus (Figure 2d), before curving to complete a C-shaped osteotomy. The resulting bone flap measures roughly 25 × 15 mm — compact enough to preserve structural integrity while providing the corridor needed.

Step 5: The inner orbital rim ridge is drilled flat with a high-speed burr to widen the working angle (Figure 2e). Juga cerebralia on the orbital roof are removed extradurally in the same step. When the lesion is particularly large, limited resection of the superior orbital rim can further extend reach without enlarging the craniotomy footprint.

Step 6: Dura is incised in a C-shape based toward the orbital rim and reflected with stay sutures (Figure 2f). The small cortical window that results is intentional — constrained by design, but directed exactly where it needs to be.

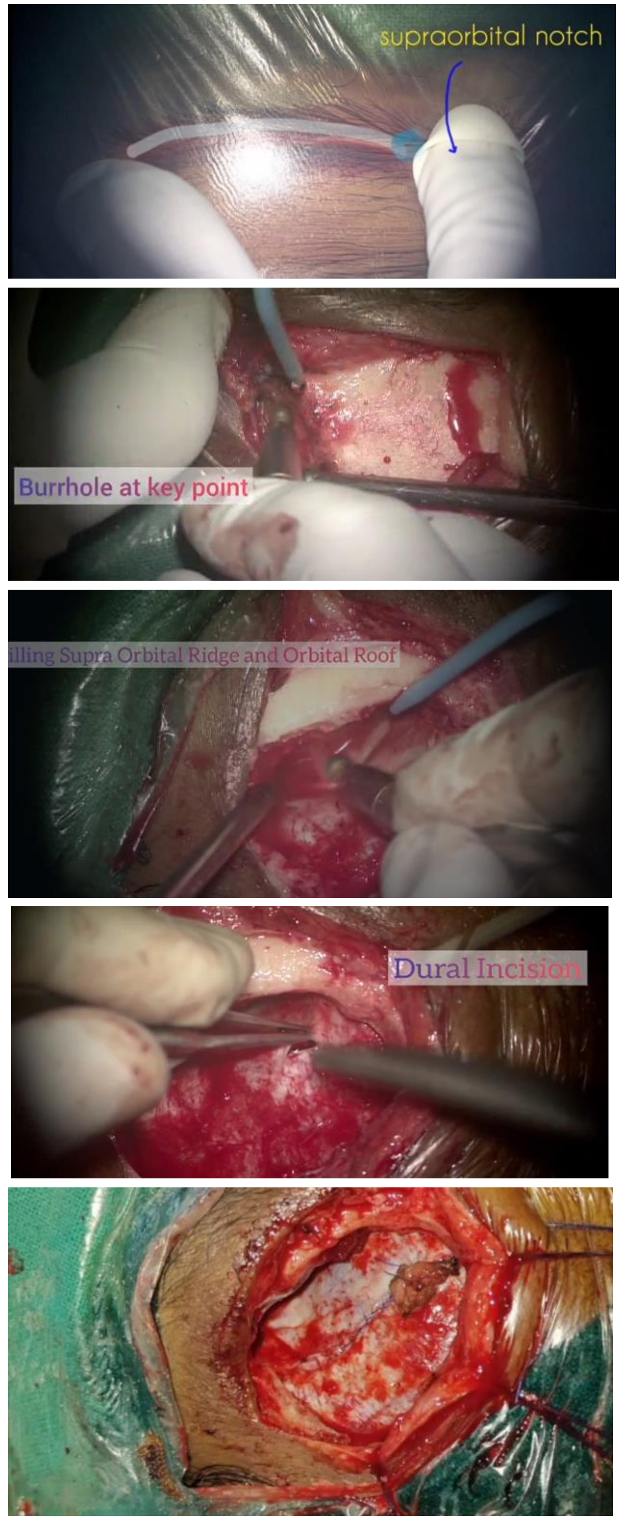


Figure 2. Operative sequence of the supraorbital keyhole approach: (a) eyebrow incision with orbital rim exposed; (b, c) frontobasal burr hole and craniotome osteotomy running

parallel to the orbital rim; (d) high-speed drilling of the orbital rim to widen the corridor; (e) C-shaped durotomy with brain surface in view; (f) watertight pericranial dural closure.

Intradural Dissection: An Illustrative Case

A 54-year-old woman gave a nine-month history of worsening anosmia, frontal headache, and subtle behavioural change. MRI revealed a large, uniformly enhancing extra-axial mass filling the olfactory groove and reaching posteriorly to the tuberculum sellae, in keeping with a meningioma (Figure 1). After multidisciplinary review, right-sided supraorbital keyhole resection was planned.

Following craniotomy and durotomy as above, a small frontal-pole patty provided gentle displacement of the frontal lobe. Even with moderate mass effect and borderline ICP elevation, the chiasmatic cistern was accessed without mechanical retractors. Stepwise CSF release from the basal cisterns relaxed the brain sufficiently to allow progressive corridor deepening throughout the case.

The tumour was first devascularised at its cribriform plate and planum sphenoidale attachment. Piecemeal debulking followed using bipolar forceps, microscissors, and CUSA, working centripetally from the tumour interior. A 0° endoscope was then substituted for the microscope, and a 30° scope used to inspect the olfactory groove recesses and verify the optic nerves and anterior cerebral complex were intact. Residual tumour deep within the groove was removed under pure endoscopic control via tube-shaft instruments. Three-month postoperative MRI confirmed complete resection with no residual enhancement.

Closure

Once haemostasis is confirmed, the dura is closed water-tight with a combination of interrupted and running 4-0 Prolene, adding a DuraGen onlay (Integra LifeSciences) where needed. The bone flap is replaced and secured with a low-profile Craniofix titanium system (Aesculap AG, Tuttlingen, Germany). Any residual margin defects are filled with Palacos bone cement (Heraeus Medical) to restore cranial contour.

Frontalis and temporalis are re-approximated with 3-0 Vicryl, followed by a subcutaneous layer, and skin is closed with subcuticular 4-0 Monocryl — eliminating return visits for suture removal. Drains are not used routinely. A light adhesive dressing is applied, taking care not to press on the supraorbital area.

Indications

This approach is best matched to pathology of the suprasellar compartment and immediately adjacent anterior skull base. Established indications include:

- Pituitary macroadenoma with suprasellar extension
- Suprasellar craniopharyngioma
- Tuberculum sellae meningioma
- Olfactory groove meningioma (small to moderate sized)
- Anterior communicating artery aneurysms
- Anterior cerebral artery aneurysms
- Selected optic sheath tumours and suprasellar epidermoids

Case selection should weigh lesion size, texture, and vascularity against the operating surgeon's keyhole experience. Tumours larger than 4 cm, or those extending significantly lateral to the ipsilateral ICA, are generally better served by a standard pterional or orbitofrontal craniotomy [13].

Limitations

Like any constrained corridor, this approach has limitations that must be anticipated rather than encountered. Table 1 lists the principal challenges alongside practical countermeasures.

Table 1. Principal limitations of the supraorbital keyhole approach and recommended mitigations.

Limitation	Solution / Mitigation
Narrow surgical corridor and limited working space	Tube-shaft instruments; angled endoscopes (30°, 45°) for visualisation beyond the direct line of sight
Unfamiliar anatomy and steep learning curve	Cadaveric laboratory training; mentorship under experienced keyhole surgeons; preoperative anatomical simulation
Risk of injury to the supraorbital nerve	Meticulous surface marking of the supraorbital notch; lateral-to-medial incision confined within the eyebrow
Elevated intracranial pressure limiting frontal lobe displacement	Preoperative mannitol; early CSF release from basal cisterns; avoidance of mechanical retractors
Inadvertent frontal sinus violation	Preoperative CT (bone window) to delineate sinus extent; wax and pericranial fascia repair if breached
Suboptimal cosmetic outcome from bone defects	Craniofix titanium plating; bone cement for residual defects; subcuticular skin closure

How to Avoid Complications

Supraorbital nerve injury: The incision should stop lateral to the supraorbital notch. Marking the notch with a skin pen before the patient is draped is a simple safeguard. Medial to the notch, dissection should be blunt to protect the nerve and artery.

Orbital entry: Siting the burr hole lateral to the temporal line at the frontal base keeps the drill clear of the orbit. Running neuronavigation throughout the osteotomy adds a continuous check that the trajectory stays extradural and above the orbital roof.

Frontal sinus entry: Bone-window CT defines the sinus footprint preoperatively. The osteotomy must stay lateral to its outer edge. If the sinus is breached, the mucosa is stripped, the cavity packed with oxidised cellulose and sealed with bone wax, and the defect covered with pericranium or abdominal fat to prevent CSF rhinorrhoea.

Periorbital haematoma: Work near the supraorbital rim should be limited and always under direct vision. Thorough haemostasis of periorbital soft tissue before closing is non-negotiable.

Raised intracranial pressure: Mannitol 1 g/kg preoperatively and a head-up position help from the outset. If the frontal lobe is still tight after durotomy, opening the chiasmatic or carotid cistern arachnoid for CSF release is the primary response. Lumbar drainage is reserved for refractory cases.

Insufficient tumour exposure: Additional orbital roof drilling and 30° or 45° endoscopes substantially widen the operative field without touching the craniotomy footprint. Preoperative MRI review of tumour consistency and vascularity helps anticipate the difficulty of piecemeal removal.

Unsatisfactory cosmesis: Subcuticular closure, precise bone reconstruction with titanium plates and cement, and foregoing drains all contribute to an acceptable scar and contour. Periorbital swelling generally settles within two to four weeks.

Specific Perioperative Considerations

Hourly neurological observations in the high-dependency unit continue for the first 24 hours. A CT brain on postoperative day one screens for haemorrhage and confirms the bone flap position. Corticosteroids are continued for 48 hours then weaned, and antiepileptic cover is given for seven days in seizure-naive patients.

Wound care is straightforward given the subcuticular closure. Most patients are discharged between days three and five, with a clinic review at six weeks. Gadolinium MRI at three months assesses resection extent and sets the baseline for surveillance.

Summary and Key Points

• The supraorbital keyhole approach through an eyebrow incision is an elegant minimally invasive corridor to the anterior skull base, offering reduced approach-related morbidity compared with conventional craniotomies.

• Preoperative planning must include detailed review of MRI and CT imaging; bone-window CT is indispensable for frontal sinus delineation.

• Head retroflexion of 15-30°, combined with appropriate rotation, enables gravitational displacement of the frontal lobe and retractor-free intradural dissection.

• The eyebrow incision must not extend medial to the supraorbital notch; the neurovascular bundle should be explicitly identified and protected.

• A single frontobasal burr hole placed lateral to the temporal line, followed by a limited C-shaped osteotomy, creates a craniotomy of approximately 25 × 15 mm.

• Extended drilling of the inner orbital rim and juga cerebralia significantly augments the effective surgical corridor without enlarging the craniotomy.

• Early CSF release from the chiasmatic and carotid cisterns is the cornerstone of retractor-free brain relaxation.

• Angled endoscopes (0° and 30°) and tube-shaft instruments are essential adjuncts that extend visualisation and manipulation beyond the constraints of the narrow corridor.

• Neuromonitoring (somatosensory evoked potentials, cranial nerve monitoring) further enhances surgical safety.

• Meticulous closure with watertight dural repair, titanium plate fixation, bone cement, and subcuticular skin sutures ensures both a safe and cosmetically satisfying result.

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Abbreviations

CN I: olfactory nerve; CN II: optic nerve; ICA: internal carotid artery; OG: olfactory groove; CSF: cerebrospinal fluid; CUSA: Cavitron Ultrasonic Surgical Aspirator; MRI: magnetic resonance imaging; CT: computed tomography; ICP: intracranial pressure; FB: frontal skull base.

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