*The Laryngoscope*


# Minimally Invasive Transfrontal Sinus Approach to Resection of Large Tumors of the Subfrontal Skull Base

Yadranko Ducic, MD, FRCS(C); Caetano Coimbra, MD

**Objectives/Hypothesis:** To review our favorable experience with a minimally invasive transfrontal sinus approach to tumors of the subfrontal region.

**Study Design:** Retrospective review in a tertiary care referral practice.

**Methods:** Patients undergoing anterior skull base surgery by the senior author (Y.D.) were reviewed and transfrontal sinus approach patients selected for review. All cases of transfrontal sinus approaches to the base of the anterior cranial fossa from 2007 to 2011 were reviewed in a retrospective fashion.

**Results:** A total of 14 cases were noted. Male to female ratio was 10 to 4 with an average age of 58.2 years. The pathologies included: meningioma (n = 6), esthesioneuroblastoma (n = 3), squamous cell carcinoma (n = 3), adenocarcinoma (n = 1), and adenoid cystic carcinoma (n = 1). Five intradural and nine extradural dissections were performed. No major complications were noted, and no patients required conversion to a traditional transfacial approach or required the use of a craniotomy. Twelve patients underwent complete tumor removal, whereas two patients underwent subtotal tumor removal. Reasons for subtotal removal were not access related but rather tumor characteristic related (carotid artery wall involvement, optic chiasm involvement). Contraindication to this approach is the presence of a hypoplastic or aplastic frontal sinus.

**Conclusions:** The minimally invasive transfrontal sinus approach to the subfrontal region provides ready expeditious access to the base of the anterior cranial fossa without the need for brain retraction, craniotomy or naso-orbital osteotomies. It represents an excellent alternative in the surgical access of both intra- and extradural tumors in this region of the skull base.

**Key Words:** Skullbase surgery, subfrontal, meningioma, frontal sinus, minimally invasive.

**Level of Evidence:** N/A.

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## INTRODUCTION

In 1913, Frazier was the first to surgically approach the base of the anterior cranial fossa through a transfrontal route.[1] The innovation and persistence of Ketcham in approaching removal of malignancies of the anterior skull base, despite complication rates approaching 80%, paved the way for modern skull base surgery.[2,3] Subsequent technical modifications were made by Tessier, who pioneered pediatric craniofacial surgery for congenital anomalies of the craniomaxillofacial skeleton.[4] These concepts, developed in pediatric orbitocranial reconstruction, served as the technical basis for subsequent innovations in transfacial approaches to the skull base. Raveh made modifications in the frontal bandeaux principle developed by Tessier, developing the so called subcranial approach to the base of the anterior cranial fossa.[5] He applied it for oncologic resection in the anterior cranial fossa/subfrontal region as well as for treatment of post-traumatic cerebrospinal fluid leaks in this region. The subcranial approach provides access for visualization and control of the cavernous sinus, orbital apex, internal carotid arteries, and ready removal of tumors of the midline and paramedian anterior fossa extending extracranially or for intraorbital or paranasal sinus tumors extending intracranially.

The major advantage of the subcranial approach is broad, safe, and expeditious exposure of the anterior cranial base with minimal brain retraction. Traditionally, one can perform a subcranial approach with a one-piece or two-piece osteotomy. In the latter approach, there is less of a tendency to generate dural tears during the transorbital osteotomy. In both cases, a craniotomy is required. Typically, it is performed superior to the level of the frontal sinus, which is either obliterated or cranialized, often at the completion of the procedure.

In this article, we will review our favorable experience with a minimally invasive transfrontal sinus approach without the need for either a craniotomy or orbitonasal osteotomies.

## MATERIALS AND METHODS

All cases of transfrontal sinus approaches to the base of the anterior cranial fossa from 2007 to 2011 were reviewed in a

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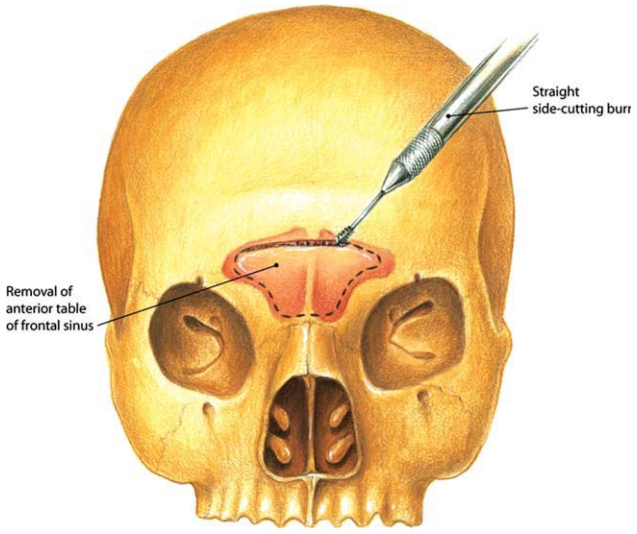


Fig. 1. Illustration demonstrating the proposed osteotomy in the anterior table of the frontal sinus.

retrospective fashion. Institutional review board approval for this study was obtained.

### *Subjects*

Patients undergoing anterior skull base surgery by the senior author (Y.D.) were retrospectively reviewed, and transfrontal sinus approach patients were selected for further review at a tertiary care referral practice.

### *Technique*

A determination is first made as to whether a minimally invasive transfrontal sinus approach to the subfrontal region is feasible. The patient's computed tomography scans are analyzed to determine the degree of pneumatization of the frontal sinus. The superior portion of the tumor should not extend appreciably beyond the superior aspect of the frontal sinus to provide for a direct approach. A standard bicoronal flap is then performed and elevated in a subpericranial fashion to the level of the nasal root and superior orbital rims. The peripheral margin of the frontal sinus is next outlined with guidance from transnasal transillumination or intraoperative computer navigation. The anterior wall of the frontal sinus is then osteotomized and kept

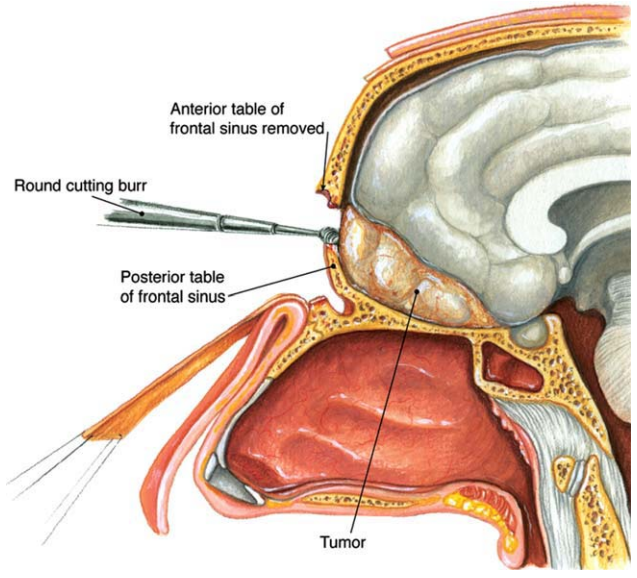


Fig. 2. Access to the posterior table of the frontal sinus facilitating removal with a round cutting burr following removal of the anterior table.

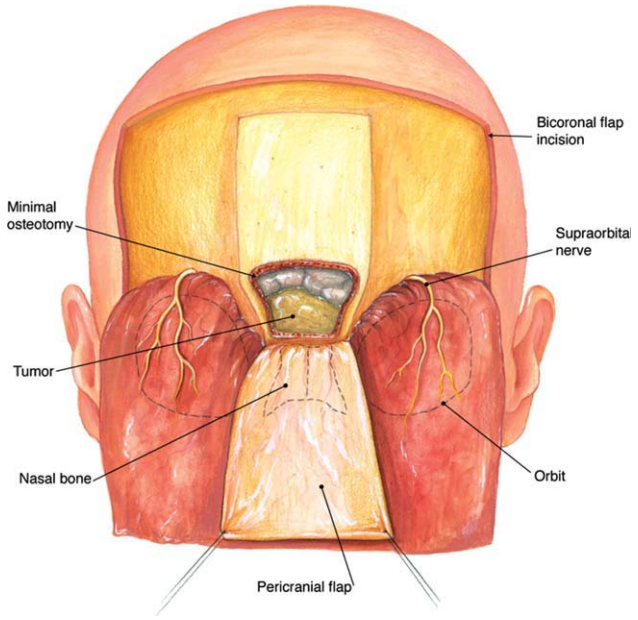


Fig. 3. Demonstration of the access gained through the minimally invasive transfrontal sinus approach for tumor extirpation.

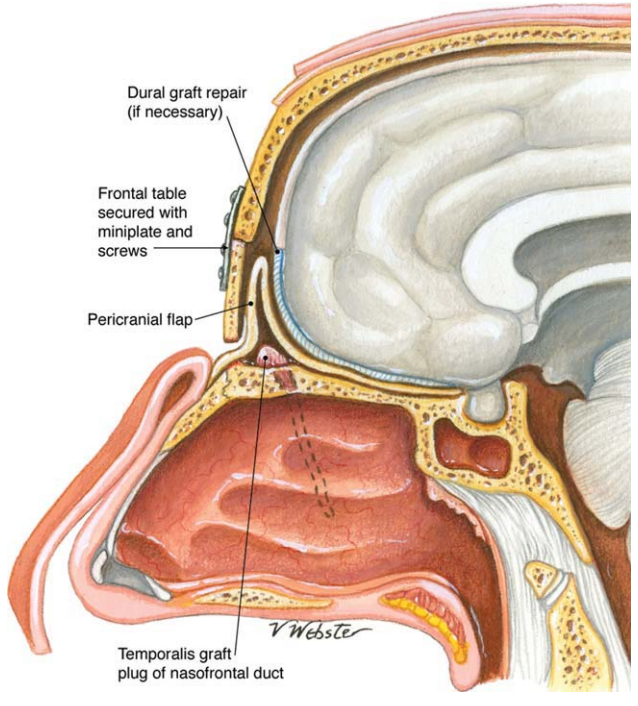


Fig. 4. Dural repair has been completed, nasofrontal duct has been plugged with a temporalis muscle graft following mucosal inversion, and pericranial flap has been laid as a protective supportive cover for the anterior cranial base.

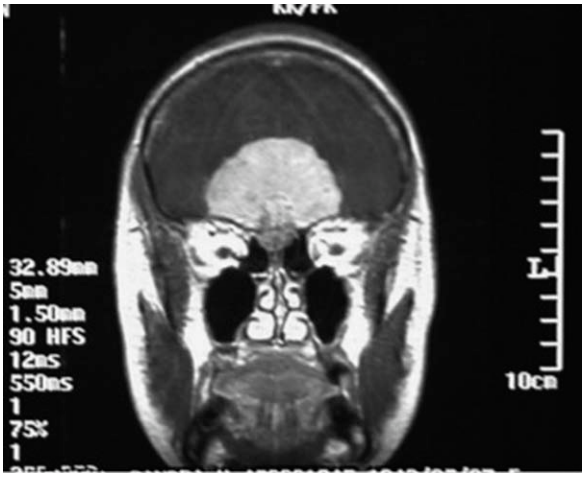


Fig. 5. Preoperative coronal magnetic resonance imaging scan of a patient with an olfactory groove meningioma.

in saline-soaked, repeatedly moistened gauze for later reinsertion. The posterior table of the frontal sinus is then removed with a round cutting burr. The edges of the transfrontal osteotomy are then thinned to improve access further. The patient's head is then angulated/positioned to allow for direct access to the subfrontal tumor without the need for brain retraction or with minimal retraction in larger tumors. This will minimize the neurologic footprint postoperatively. Once the tumor has been removed, mucosa is drilled with a round burr from the inner aspect of the anterior bone flap, and the nasofrontal ducts are plugged with a combination of invagination of native mucosa and temporalis muscle (or other fascia) plug. Dura is closed or replaced with tensor fascia lata, homograft dura, or collagen construct in cases of dural loss/sacrifice. An anteriorly based pericranial flap is then inset along the base of the anterior cranial fossa in a standard accordion fashion. The anterior wall of the frontal sinus is then replaced and secured with miniplates to the surrounding frontal bone. Closure of the bicoronal flap with short-term suction drains brought out away from the frontal region is then performed (Figs. 1–10).

## RESULTS

A total of 14 cases were noted. Male to female ratio was 10 to 4 with an average age of 58.2 years. The

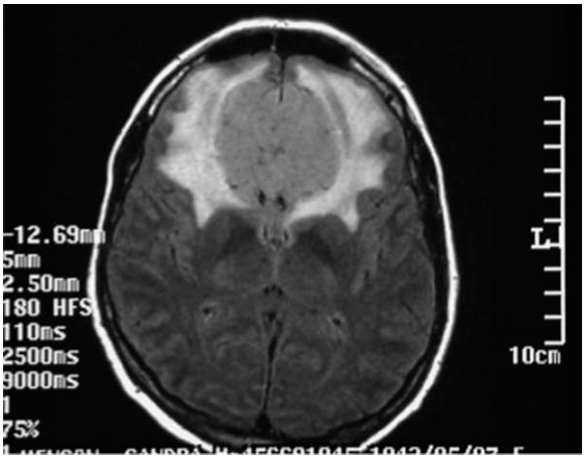


Fig. 6. Preoperative axial magnetic resonance imaging scan of patient in Figure 5. Note tremendous amount of surrounding brain edema.

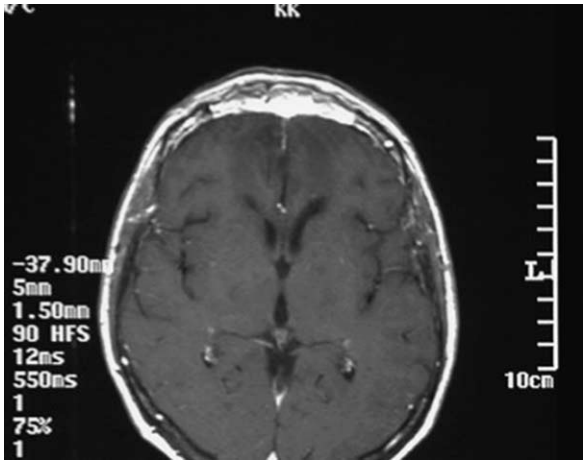


Fig. 7. Postoperative axial scan of patient in Figures 5 and 6 demonstrating complete tumor removal with lack of neurologic footprint (lack of flare noted in surrounding brain parenchyma).

pathologies included: meningioma (n = 5), esthesioneuroblastoma (n = 3), squamous cell carcinoma (n = 3), adenocarcinoma (n = 2), and adenoid cystic carcinoma (n = 1). Five intradural and nine extradural dissections were performed. No major complications were noted, and no patients required conversion to a traditional transfacial approach or required the use of a craniotomy. Tumor size was average diameter of 4.3 cm (range, 2.5–9 cm). Twelve patients underwent complete tumor removal, whereas two underwent subtotal tumor removal. Reasons for subtotal removal were not access related but rather tumor characteristic related (carotid artery wall involvement, optic chiasm involvement). Contraindication to this approach is the presence of a hypoplastic or aplastic frontal sinus.

No long-term problems with the frontal sinus were encountered. The frontal sinus was cranialized in each of our cases. No cases of cerebrospinal fluid leaks were noted in any of our patient population.

## DISCUSSION

The subcranial approach, as originally described, represents an excellent alternative to accessing the

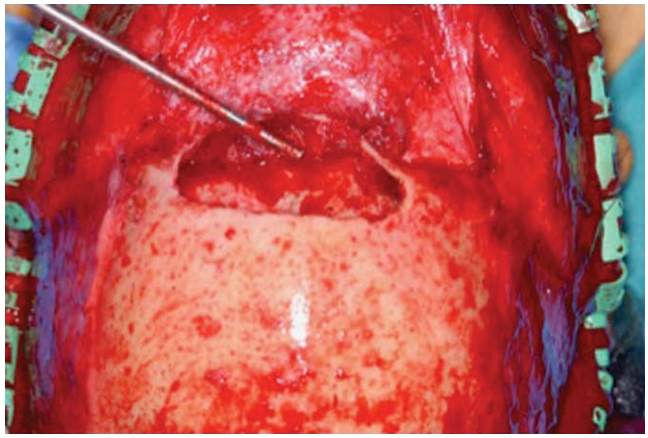

Fig. 8. Intraoperative view of patient undergoing transfrontal sinus approach for intracranial inverting papilloma following removal of anterior table of frontal sinus.

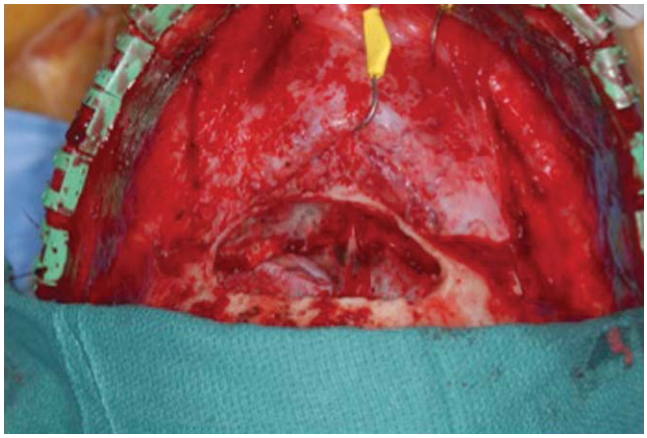

Fig. 9. Intraoperative view of patient in Figure 8 following removal of posterior table of frontal sinus exposing the tumor.

subfrontal region for oncologic resection and reconstruction, as in the case of traumatic disruption. We have used this approach with success in a large number of patients and find it rewarding in terms of ease of use, time to perform, and minimal effects on surrounding brain tissue. Over time, we have modified the subcranial approach as originally described by Raveh, by progressively limiting the extent of the osteotomies that we use for access. This decrease in the size of the osteotomized subcranial segment (fronto-orbital bar and nasal root) lead us to the minimally invasive approach described herein. This approach provides ready access to this region. Both approaches have minimal need for brain retraction. However, a significant number of issues need to be addressed in the patient undergoing a standard subcranial approach that are not an issue in our transfrontal sinus approach. These issues include: nasoseptal framework reattachment, lacrimal stenting, medial canthal reattachment, as well as the need for upper gingivobuccal access to plating the nasofrontal region along the medial maxillary buttress. Detachment of the trochlea, need for orbital content retraction, and need to remove/osteotomize portions of the anterior cranial fossa even in cases of completely intracranial subfrontal tumors make the subcranial approach potentially more fraught with problems in postoperative appearance and function. Although we have described elsewhere our techniques for optimizing reconstruction in this patient population with favorable outcomes, avoiding the need for such procedures, when feasible, should result in a decrease in the length of these operations (difficult to quantitatively compare due to patient and tumor variability) as well as simplifying them.[6,7]

The minimally invasive transfrontal sinus approach seems to be worthwhile considering cases of a well-pneumatized frontal sinus, whose superior extent on sagittal view extends to or above the superior-most portion of the subfrontal tumor one is attempting to access. One can certainly widen in the lateral or superior dimension the access portal following removal of the anterior wall of the frontal sinus, although we have rarely found this to be necessary. Historically, this is similar to an osteoplastic flap that is not pedicled. This allows excellent access to posterior wall removal and lateral extension if needed. As in all skull base surgery, meticulous attention to dural closure/repair/replacement and separation of the intracranial from extracranial compartments with as watertight a closure as possible is a standard goal in this approach as well. Although minimally invasive in terms of approach, we feel this approach provides for a more direct, less angulated approach to the subfrontal region than standard subcranial approaches, permitting a shorter distance between the surgeon and the tumor. In cases of aplasia or hypoplasia of the frontal sinus, this approach cannot be utilized. Substituting it for a simple bifrontal craniotomy would often result in an unfavorable angle of access to the tumor requiring brain retraction. An alternate approach should then be considered. Endoscopic approaches to the subfrontal skull base are certainly possible, and we use them often in our practice. The advantage of the transfrontal approach is that the skull base bone and intranasal mucosal lining protective layers are preserved while accessing tumors with minimal involvement of these structures. Endoscopic approaches will require wide removal of these structures for adequate access.

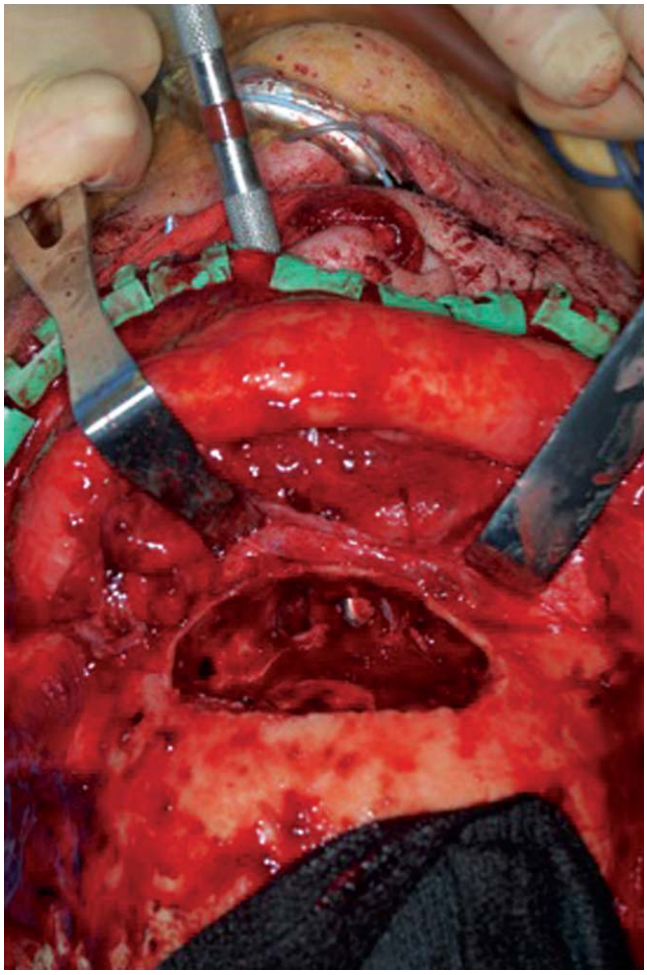

Fig. 10. Intraoperative view following complete subfrontal tumor removal. Note intranasally placed instrument.

Chronic frontal sinusitis is not a contraindication to this approach as the frontal sinus is cranialized, removing this as an issue for the patient.

We encountered no significant problems with this approach and have found it to be associated with a minimal neurologic footprint as seen by lack of flare on postoperative T2 weighted magnetic resonance imaging sequences, signifying minimal surrounding brain parenchymal edema due to minimal need for brain retraction.

## CONCLUSION

The minimally invasive transfrontal sinus approach to the subfrontal region provides ready expeditious access to the base of the anterior cranial fossa without the need for brain retraction, craniotomy, or naso-orbital osteotomies. It represents an excellent alternative in the surgical access of both intra- and extradural tumors in this region of the skull base, providing excellent direct safe exposure. It negates the need for surgical correction of nasal root position, lacrimal drainage reestablishment, and canthal repositioning.

## BIBLIOGRAPHY


1. Frazier CH. An approach to the hypophysis through the anterior cranial fossa. *Ann Surg* 1913:57:145–148.
2. Ketcham AS, Hoyle RC, Van Buren JM, Johnson RH, Smith RR. Complications of intracranial facial resection for tumors of the paranasal sinuses. *Am J Surg* 1966:112:591–595.
3. Ketcham AS, Wilkins RH, Van Buren JM, Smith RR. A combined intracranial facial approach to the paranasal sinuses. *Am J Surg* 1963:106: 698–703.
4. Tessier P, Guiot G, Rougerie J. Cranio-orbitofacial osteotomies for hypertelorism [in French]. *Ann Chir Plast* 1967:12:103–118.
5. Raveh J. Modified frontobasal approach. *Chirurgie* 1983:54:677–686.
6. Ducic Y. Medial canthal ligament attachment in skull base surgery and trauma. *Laryngoscope* 2001:111:734–738.
7. Ducic Y, Pontius AT. Nasal reconstruction in surgery of the anterior skull base. *Otolarygol Head Neck Surg* 2004:130:176–186