

Transsphenoidal Pituitary Resection

Last updated: January 16, 2021

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USED SOURCES

Townsend: **Sabiston** Textbook of Surgery, 16th ed., 2001 (p. 662-671, 1527-1528)

Marshall B. Allen, Ross H. Miller "Essentials of Neurosurgery: a guide to clinical practice", 1995 (211-228 p.); Publisher: McGraw-Hill, Inc.; ISBN-10: 0070011168; ISBN-13: 978-0070011168

R. **Jandial** "Core Techniques in Operative Neurosurgery" (2011), procedure 9

Guidelines on the Management of Patients with Nonfunctioning Pituitary Adenomas (**CNS 2016**)

Badie "Neurosurgical operative atlas - Neuro-oncology" 2nd ed., 2007 (p. 1-8)

Nader "Neurosurgery Tricks of the Trade – CRANIAL", 2014 (p. 257-263)

Rhoton collection – Anterior Skull Base, part 2 >>

OVERVIEW OF PITUITARY SURGERY

Typical pathway is **TRANSSPHENOIDAL APPROACH** – gold standard – high safety and efficiency (incl. **MICROADENOMAS** confined to sella and larger tumors that, in past, could be approached only by subfrontal craniotomy)!

- possible for fairly large medial suprasellar extensions, as long as tumor is soft (usual case) and can drop into sella with progressive resection (alternatively: follow postop MRI – when remaining tumor falls down → second look surgery)
- approach was originally developed by **Cushing** and popularized by others, especially **Hardy**.
- less surgical morbidity than transcranial approaches – transsphenoidal approach avoids brain retraction, does not create visible scars, and provides excellent visualization of the pituitary.

Think that sella-sphenoid sinus is "pelvis" and tumor is "baby" – look at MRI if baby can be delivered vaginally (transsphenoidal) or needs C-section (subfrontal)

If sella is not enlarged, transsphenoidal approach is contraindicated!

- sella can be approached by three transsphenoidal approaches:
 - a) direct transnasal – endoscope (ENT) or microscope (**Dr. JRC**)
 - b) anterior (trans)septal
 - c) sublabial (trans)septal

If tumor will be difficult to deliver transsphenoidally, think about **CRANIOTOMY**:

1. Subfrontal
 2. Interhemispheric
 3. Pterional
 4. Subtemporal
- when choosing craniotomy approach, consider the following:
 - 1) position of **chiasm** (esp. is it prefixed)
 - 2) position of **AComA-ACA complex**; AComA perforators (go superiorly from AComA) are very friable!
 - 3) position of **fornix**

Indications for **subfrontal approach**:

- a) **woody** suprasellar tumors, esp. when primary purpose is to decompress optic nerves
 - b) **lateral extension** into middle fossa
 - c) **anterior extension** beneath frontal lobes.
- frontal lobe is carefully retracted, exposing optic nerves and ipsilateral carotid artery (N.B. only by subfrontal approach one can visualize *both* optic nerves and carotid arteries).
 - if chiasm is prefixed (severely limited view of tumor mass) - resect tuberculum sellae and open sphenoid sinus.

Pterional and Subtemporal approaches are used for **parasellar tumors** (**MENINGIOMAS, CHORDOMAS**).

See also craniopharyngioma aspects >>

Check for: sinusitis, nose trauma, OSA (obstructive sleep apnea), ossified / small sphenoid sinus.

Make sure you are not operating on undiagnosed **prolactinoma!** see p. Onc26 >>

Make sure **visual changes** are documented!

N.B. some antisecretory medications can lead tumors to be denser and more fibrotic - technically more challenging to remove during microsurgery; H: **stop medications 4-6 weeks preop!**

IMAGING

Always load CT and MRI for navigation! – segment **tumor, carotids, optic nerves & chiasm, bone** which could be taken safely.

- CT** (Dr. Holloway likes to use it for navigation)
 - look for **nasal septum** deviation (on CT) – which side to approach
 - look at **intra-sphenoid sinus septum** (on CT) – which side is sellar floor bulging, where septum leads (e.g. carotid – better not to remove such septum) – careful taking it (always use bur and not breaking instruments)
- MRI** (Dr. Broaddus)
- CTA** – if high risk of carotid injury during surgery; if circle of Willis is incomplete (cannot expect carotid cross-filing) – cannot sacrifice carotid if injury happens.

N.B. review imaging carefully for **position of carotids!** (look for “kissing” carotids)

CONTRAINDICATIONS

- kissing carotid arteries** - abutting in the sellar space and closer than 4 mm from the midline.
- presellar type of sphenoid sinus.
- involvement of the lateral carotid compartment, such as in invasive pituitary adenomas, is no longer considered a limitation to the transsphenoidal approach.

APPROACHES

- the **microscope** affords magnification, illumination, 3D viewing, and **two instruments simultaneously**;
- the **endoscope** **expands the surgeon’s field of view**.
- both tools can be used simultaneously to complement each other.
- microscopic surgery is preferred in presellar type sphenoid sinus and flat sellar floor.

COMPARISONS

Guidelines on the Management of Patients with Nonfunctioning Pituitary Adenomas (CNS 2016)
Level III recommendation: Transsphenoidal **microsurgery or endoscopic** resection is recommended for symptomatic relief.
Level III recommendation: **Transsphenoidal approach** is recommended for NFPA resection in **ASA grade 1-3 elderly patients**
Level III recommendation: **Adequate bony exposure** of the sphenoid and sellar regions is recommended to **improve extent of NFPA resection**.
Level III Recommendation: **Endoscopic approaches** are recommended for better visualization of **portions of tumors remaining after standard microsurgery** (in multiple Class III studies direct endoscopic visualization revealed residual tumor tissue after initial microsurgery).
Level III Recommendation: For select, **invasive NFPAs with significant suprasellar, frontal, and/or temporal extension**, the **combined transsphenoidal and transcranial** surgical strategy is recommended.

Pituitary surgery - **endoscopic vs. microscopic:**
Comparison of Complications, Trends, and Costs in Endoscopic vs Microscopic Pituitary Surgery: Analysis From a US Health Claims Database. Anthony O. Asemota et al. Neurosurgery 2017

- patients who underwent **endoscopic surgery** were more likely to develop **DI** (odds ratio [OR] = 1.48; 95% CI = 1.28-1.72), **SIADH** (OR = 1.53; 95% CI = 1.04-2.24), **hyposmolality / hyponatremia** (OR = 1.17; 95% CI = 1.01-1.34), **CSF rhinorrhea** (OR = 2.48; 95% CI = 1.88-3.28), **other CSF leak** (OR = 1.59; 95% CI = 1.28-1.98), **altered mental status** (OR = 1.46; 95% CI = 1.01-2.60), and **postoperative fever** (OR = 4.31; 95% CI = 1.14-16.23).
- no differences in hemorrhagic complications, ophthalmological complications, or bacterial meningitis.

CSF leakage, olfactory disturbances postop - **endoscopic vs. microscopic:**
Laryngoscope. 2013 Sep;123(9):2112-9. doi: 10.1002/lary.24037. Epub 2013 Jul 8. Olfactory functions after transsphenoidal pituitary surgery: endoscopic versus microscopic approach. Kahilogullari G1, Beton S, Al-Beyati ES, Kantarcioglu O, Bozkurt M, Kantarcioglu E, Comert A, Unlu MA, Meco C.

- prospective study – 25 pts operated on with the endoscopic approach and 25 patients operated on with the microscopic transsphenoidal approach
- Smell Diskettes Olfaction Test was used during the preoperative period, 1 month after the operation, and 6 months after the operation.

	endoscopic group	microscopic group
hyposmia	8%	52%
anosmia	0%	20%
CSF leakage	36%	40%
synechia	4%	36%

OR EQUIPMENT

- Navigation / fluoroscopy (Dr. Holloway)
- Microscope
- Endoscopes
- Doppler
- Lumbar drain

Guidelines on the Management of Patients with Nonfunctioning Pituitary Adenomas (CNS 2016): **insufficient evidence** to recommend **perioperative CSF diversion** to prevent postop CSF leak.

PREPARATION IN OR

- particular importance - **replacement of adrenal insufficiency and significant hypothyroidism** in perioperative period (**HYDROCORTISONE** 100 mg 12 hours prior to surgery, 100 mg just prior to surgery; 100 mg q8hrs after surgery, taper* over 3-7 days to maintenance 20 + 10 mg). *if BP tolerates

Guidelines on the Management of Patients with Nonfunctioning Pituitary Adenomas (CNS 2016)

Level II Recommendations: replacement for adrenal insufficiency and significant hypothyroidism is recommended in all patients preoperatively.

Level III Recommendations: perioperative corticosteroid supplementation is recommended for NFPA patients with preoperative or immediate postoperative (day 2) hypocortisolemia.

i.e. not for patients with normal adrenal function

- systemic antibiotics** (**CEFAZOLIN / CLINDAMYCIN / CEFTRIAXONE**) are used prophylactically (some surgeons prefer topical antibiotics on nasal mucosa).
- anesthesia:** general oral endotracheal; tape ET tube down to lower lip.
- supine **position** with head:
 - on gel donut (**Dr. Holloway**) – neck extended, head rotated slightly towards operator.
 - in Mayfield frame (**Dr. Broaddus**) - neck in extended sniffing position - nose tip remains vertical – operative trajectory straight down; others recommend head slightly tilted to the patient's left (10 to 15 degrees), rotated to the right (10 to 20 degrees), and slightly extended.
- nose and oropharynx with Betadine solution (ENT does not do that for endonasal approach!).
- pack nose with **OXYMETAZOLINE*** / **PHENYLEPHRINE** / **COCAINE** solution pledgets. *e.g. Afrin®
- Kerlix oral cavity packing** to prevent blood drainage into stomach → postop vomiting → aspiration.

N.B. may forget there – ask anesthesia to place warning tape on their gas machines for reminder!
- consider prepping abdomen (above waist line) for fat graft* harvesting (**Dr. Broaddus** thinks that fat graft results are inferior). *or thigh for fascia lata

Dr. Holloway likes to harvest fat as a first step as it is clean part!
- lumbar drain:**
 - may place preop if expect CSF leak – tumor goes and likely breaches diaphragm of sella;
 - may place preop if tumor goes above sella – may inject saline through lumbar drain to push tumor into sella
 - place postop PRN
 - skip at all.

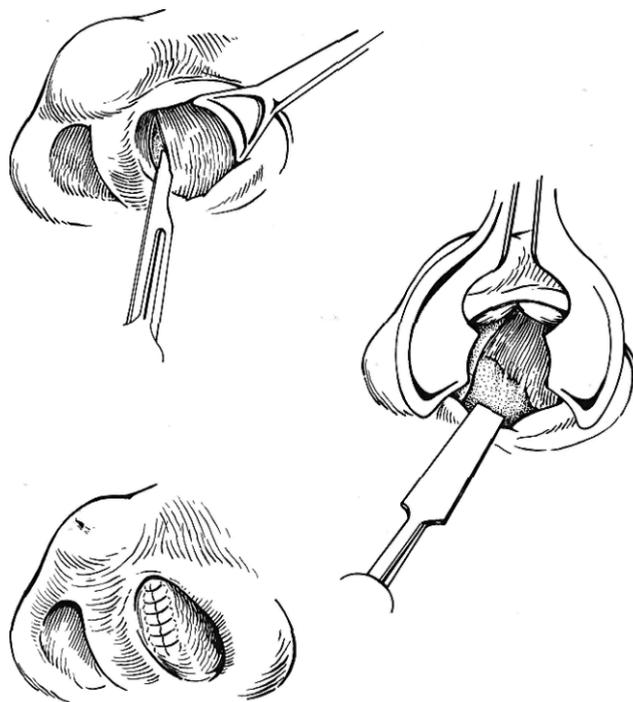
Dr. Broaddus – it is hard to predict CSF leak from MRI features; prefers to place lumbar drain at the end of case only if needed (same with **Dr. Holloway**).

TRANSNASAL approach

- use **nasal speculum** for retraction (not Hardy retractor!).
- once close the sphenoid sinus, speculum is rotated to break posterior septum (position is verified with navigation to avoid fracture into orbit!).

PURELY SEPTAL approach

- anterior inferior nasal septum** and **septal mucosa** infiltrated with 0.25-1% lidocaine with epinephrine 1:100,000 or 1:200,000 (**Dr. Broaddus** uses only epinephrine); ENT also infiltrates palatine foramina from oral cavity side.
- vertical incision in septal mucosa (additional small incision in ala if it is necessary to enlarge nostril enough for speculum):

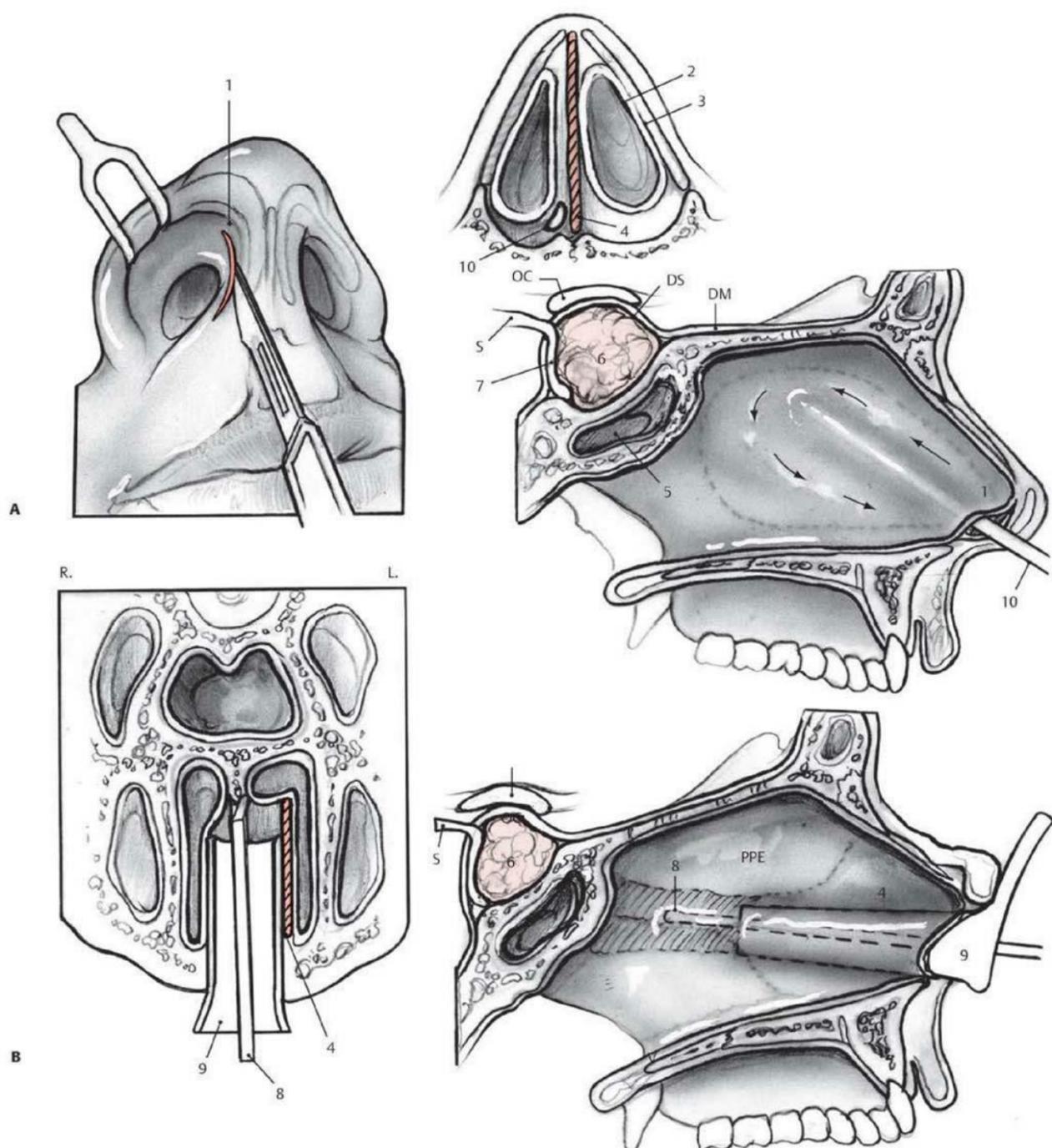


(B)

Source of picture: Marshall B. Allen, Ross H. Miller "Essentials of Neurosurgery: a guide to clinical practice", 1995; McGraw-Hill, Inc.; ISBN-13: 978-0070011168 >>

- use **nasal speculum** for retraction (not Hardy retractor!).
- once inside the sphenoid sinus, position is verified with lateral **fluoroscopy** view.
- Dr. Holloway** puts fat graft into sphenoid sinus and sprays Tisseel; she does not use any bone for reconstruction.

(A) A mucosal incision is made following the inferior border of the septal cartilage from an anterior to posterior direction. Axial sections and through the nasal aperture show the relation of the septal cartilage with surrounding mucosa and the dissection plane direction. (B) A submucosal plane is developed using an elevator in the direction of the sphenoid sinus. After performing the initial incision, a mucoperichondrial flap is then elevated from the septum. (Inset) Anatomic landmark inside the sphenoid sinus. 1. Hemitransfixion incision; 2. elevate mucoperichondrial flap from septum; 3. Lateral upper cartilage; 4. septal cartilage; 5. sphenoid sinus; 6. tumor; 7. pituitary; 8. punch; 9. self-retaining nasal speculum; 10. elevator. DM, dura mater. oc. optic chiasm; DS, dorsum sella; s. stalk; V, vomer. PPE, perpendicular plate of the ethmoid.

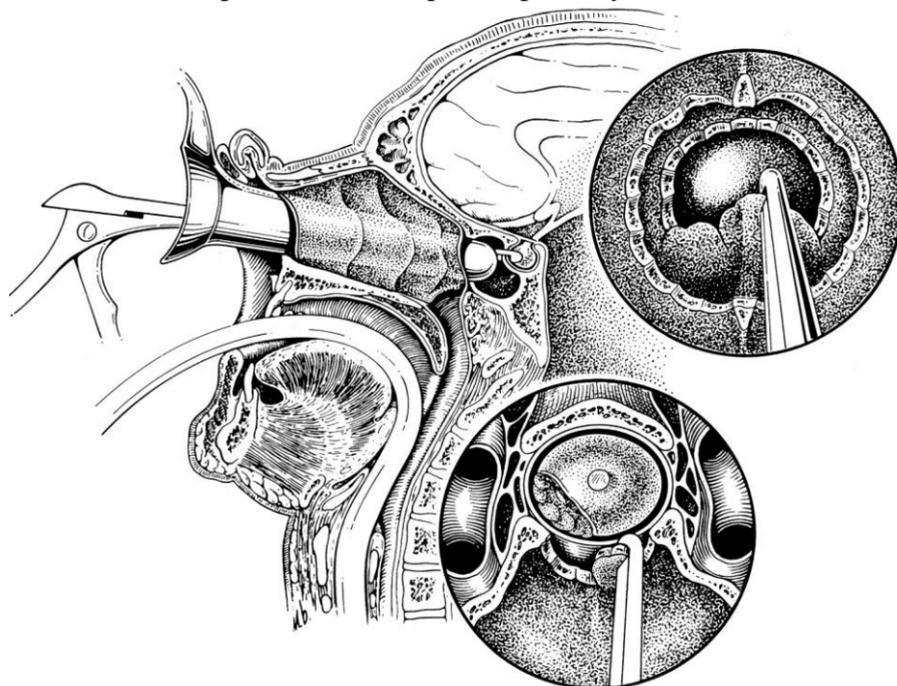


SUBLABIAL-SEPTAL APPROACH

- maxillary gingiva and anterior inferior nasal septum (through lip skin) infiltrated with 1% lidocaine with epinephrine 1:100,000 (Dr. Broaddus uses only epinephrine).

Top inset - removal of sella floor with small rongeurs.

Bottom inset - exposed inferior aspect of pituitary adenoma.



Source of picture: David C. Sabiston "Sabiston Textbook of Surgery: the Biological Basis of Modern Surgical Practice", 15th ed. (1997); W.B. Saunders Company; ISBN-13: 978-0721658872 >>

INCISION

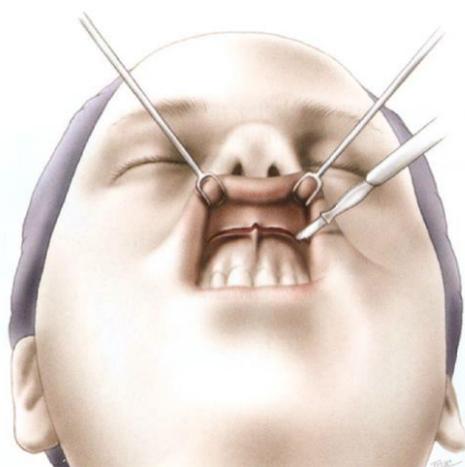
- beneath upper lip - curvilinear anterior maxillary oral **gingival / lip** (preferred)* mucosa incision from canine-to-canine (few mm from gingival fold) with # 15 blade down to the bone:

*incise lip – better mucosal cuff for repair, less straightforward path for CSF leak, lesser chances of gum numbness

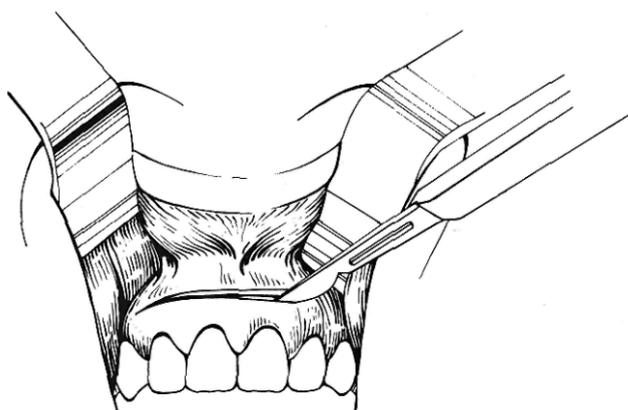
Leave enough of mucosal cuff for repair!

Keep the lip protected with *bacitracin ointment* application!

Recommended:

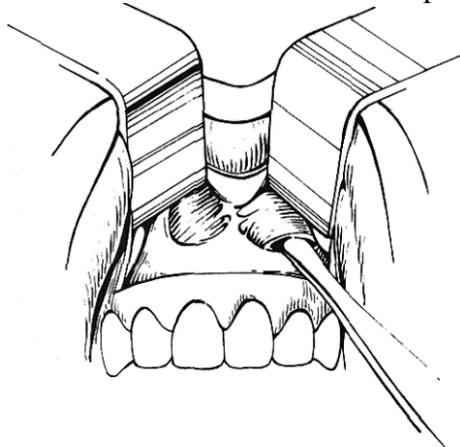


Not recommended:



Source of picture: Marshall B. Allen, Ross H. Miller "Essentials of Neurosurgery: a guide to clinical practice", 1995; McGraw-Hill, Inc.; ISBN-13: 978-0070011168 >>

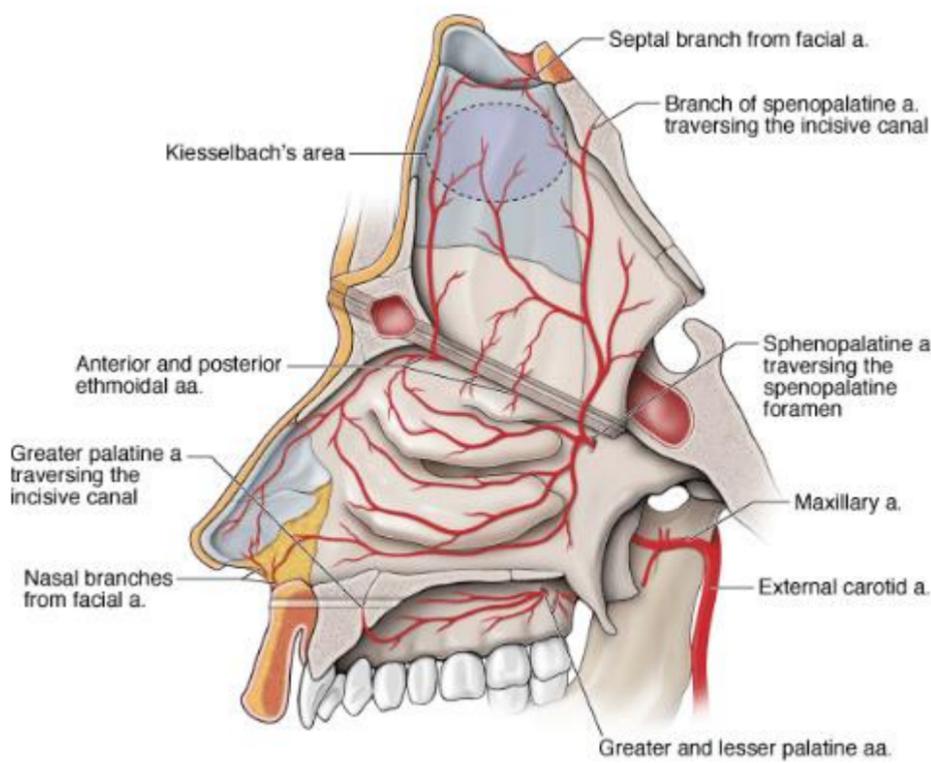
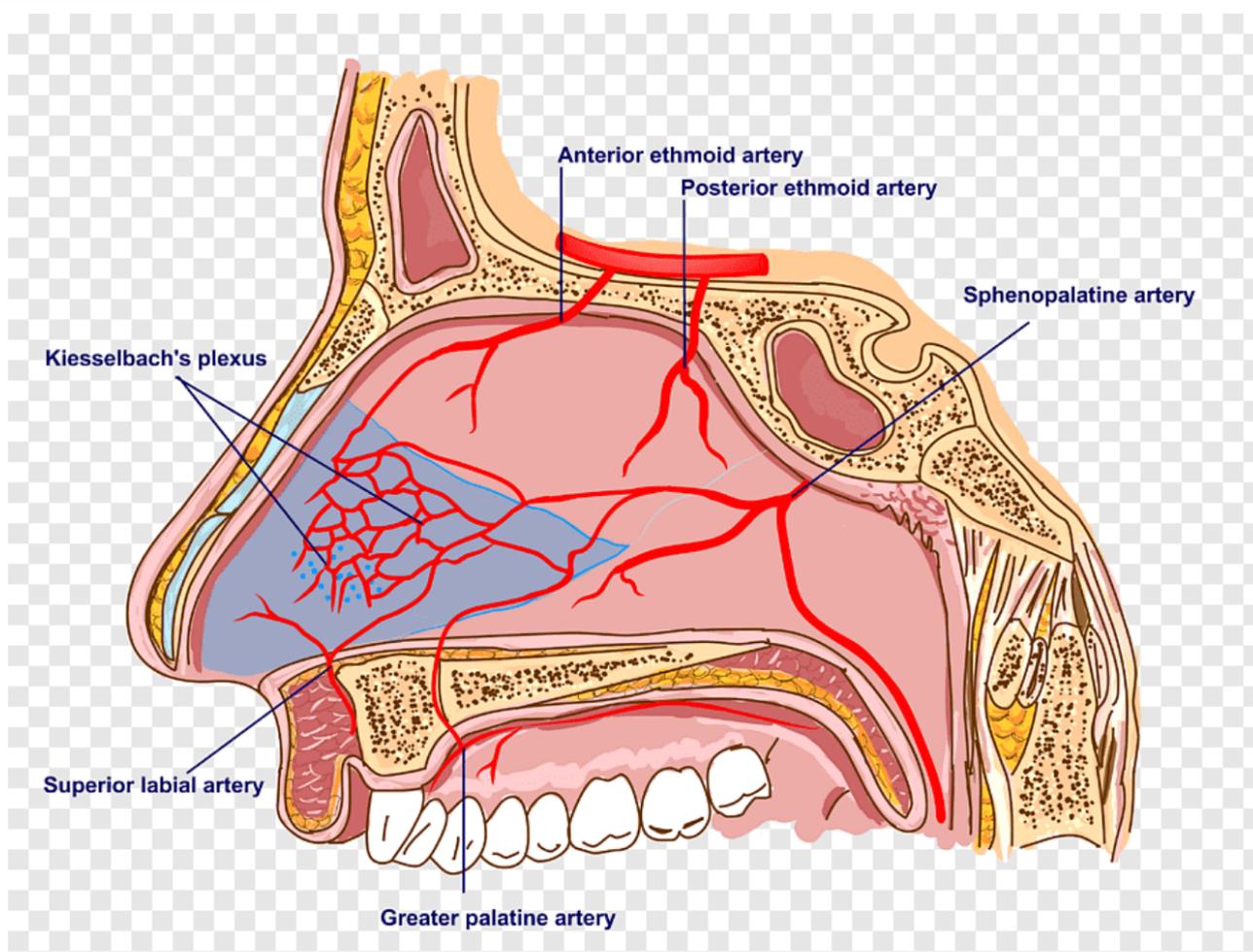
- Penfield #1 / Freer dissector used to dissect up maxillary bone to inferior maxillary choanal ridge:



(A)

Source of picture: Marshall B. Allen, Ross H. Miller "Essentials of Neurosurgery: a guide to clinical practice", 1995; McGraw-Hill, Inc.; ISBN-13: 978-0070011168 >>

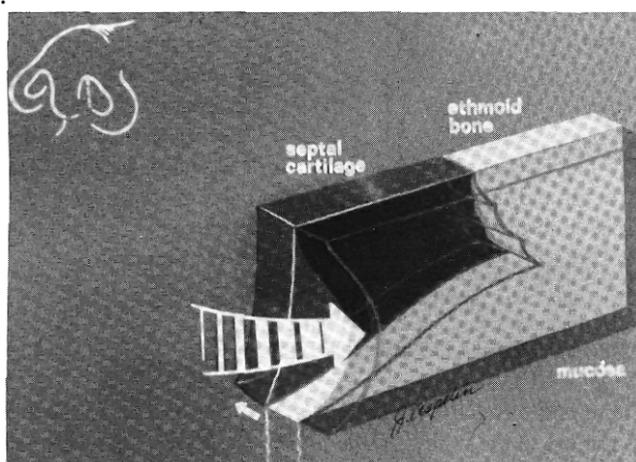
DISSECTION



- elevate nasal mucosa on both sides of nasal floor (hard palate) staying on bone with Freer dissector / Penfield # 1 → elevate mucosa from right side of cartilaginous septum with Penfield #2 (its blunt edge helps to not perforate mucosa) → inferior portion of cartilaginous septum is detached from maxillary spine using # 15-blade / Freer and reflected to the side → elevate mucosa from bony septum back to the vomer:



- **Hubbard** or **Hardy retractor** is inserted and dissection continued with the navigation used to verify positioning.



Source of picture: Marshall B. Allen, Ross H. Miller "Essentials of Neurosurgery: a guide to clinical practice", 1995; McGraw-Hill, Inc.; ISBN-13: 978-0070011168 >>

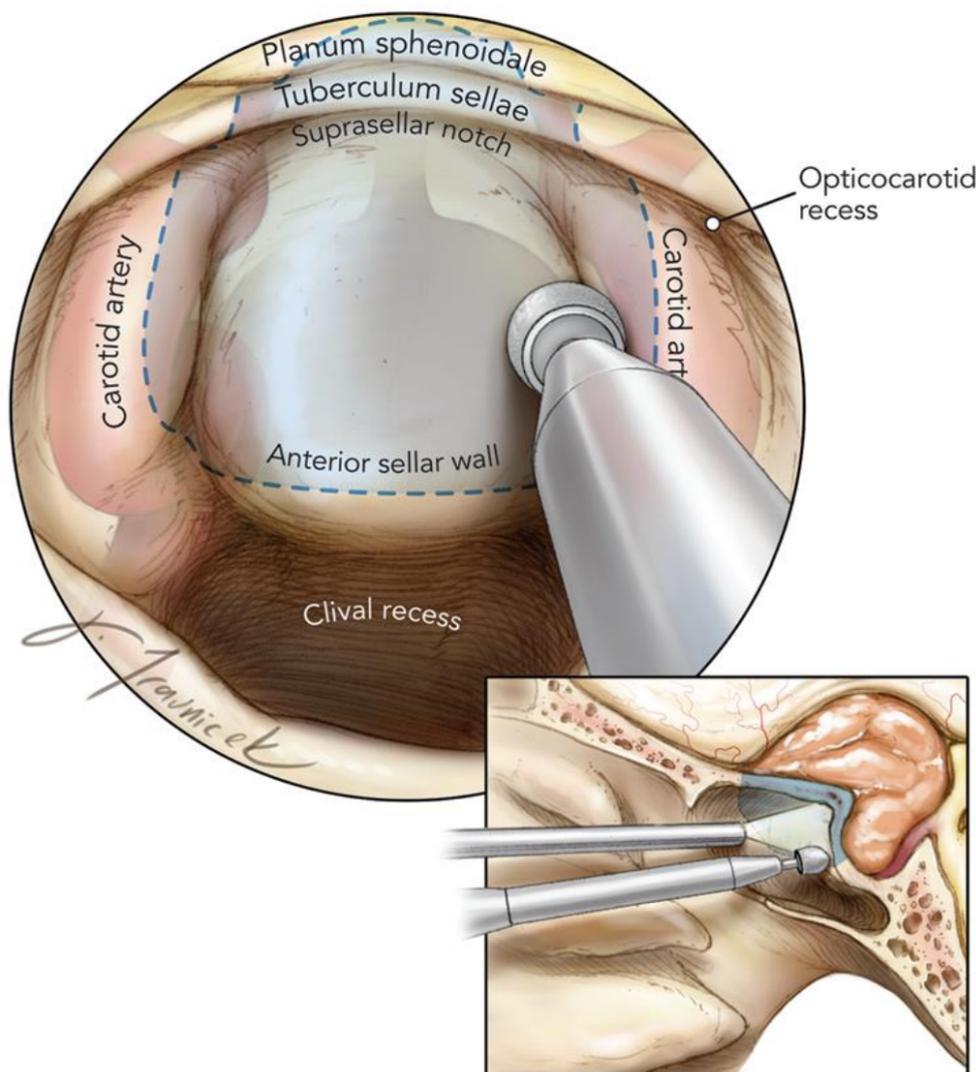
- bony septum is removed with **pituitary rongeur / Jansen-Middleton Septum Forceps** (save large bone pieces for implantation on sella floor inside sphenoid sinus at time of closure):



N.B. all dissection must proceed **as much cephalad (superiorly) as possible** – superior part of sphenoid sinus is the most difficult to visualize!

- dissection continued posteriorly to rostrum of sphenoid sinus.
- mucosa is dissected from anterior wall of sphenoid sinus.
- sphenoid sinus is entered at rostrum and ostia using **osteotome/chisel**.
- removed portion of anterior sinus wall is saved for reconstruction.
- once inside sphenoid sinus, **mucosa is removed** (beware dehisced bone and exposed carotid!); if left in place - risk of **mucocele** (esp. if Hadad-Bassagasteguy vascularized naso-septal flap is used)
N.B. others recommend removing mucosa only from sella!
N.B. tips of the retractor should never be placed into the sphenoid sinus (after the completion of the anterior sphenoidotomy) - overexpansion of the retractor can fracture the sphenoid bone and the optic canals → catastrophic optic nerve injury.
- floor of the sella turcica reveals itself as a smooth bulge in the superior midline region of the sinus.
- MICROSCOPE is brought into field.
- it is best to prepare the widest possible surgical field: removing the middle turbinate (not necessary in microadenomas), performing a wide sphenoidotomy (from one sphenopalatine artery to the contralateral one, exposing both ICAs), opening the sella from the inferior intercavernous sinus to the superior one and from one cavernous sinus to the contralateral one, cruciate dural opening with coagulation of the margins and coagulation of the inferior intercavernous sinus also serves to widen the working area.

Extended sella exposure (needed for tuberculum sellae meningiomas):



Reproduced from Aaron A. Cohen-Gadol: The Neurosurgical Atlas.

TUMOR REMOVAL

See below >>

CLOSURE

- hemostasis is achieved using bipolar electrocautery, packing with Gelfoam with Surgicel, pledgets, and SurgiFoam.
- if there is **CSF leak** and no lumbar drain, lower head of the table to drain some CSF and then elevate it to stop CSF leak.
- **sella maybe packed** with:
 - a) Gelfoam
 - b) fascia lata – may cause thigh muscle herniations
 - c) fat (± wrapped in Surgicel – “Surgicel sling”) – only if there is CSF leak.

N.B. sphenoid sinus itself is not packed with fat! (case report of blindness from too big of fat graft jammed into sella; plus, fat obscure postop MRI although fat gets absorbed over many months); fat is good as onlay.

N.B. any placement of intracranial fat will obscure postoperative imaging of residual tumor! (Dr. Caldwell: fat gets absorbed and allows perfect MRI follow ups compared to using titanium mesh or Medpor)

Fat graft inside sella:

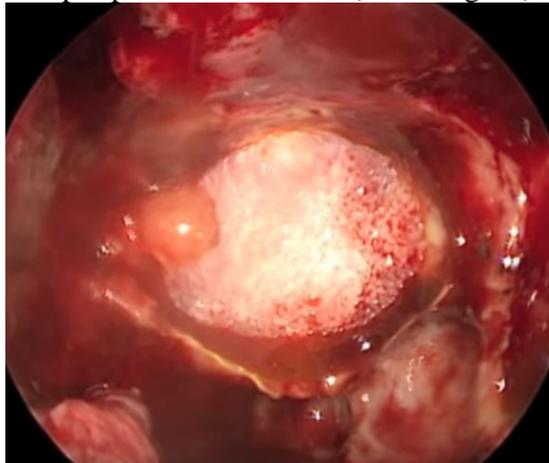


- **bone** (e.g. nasal septum) fragment / **Medpor patch** is placed intradurally to close entrance into sella followed by **nasoseptal flap**** (optional) and then **DuraSeal*** spray (through Angiocath threaded through the ring of curette).

*some experts do not use it

**make sure mucosal surface is outside (else will form mucocele)

Medpor patch in sella floor (over fat graft):

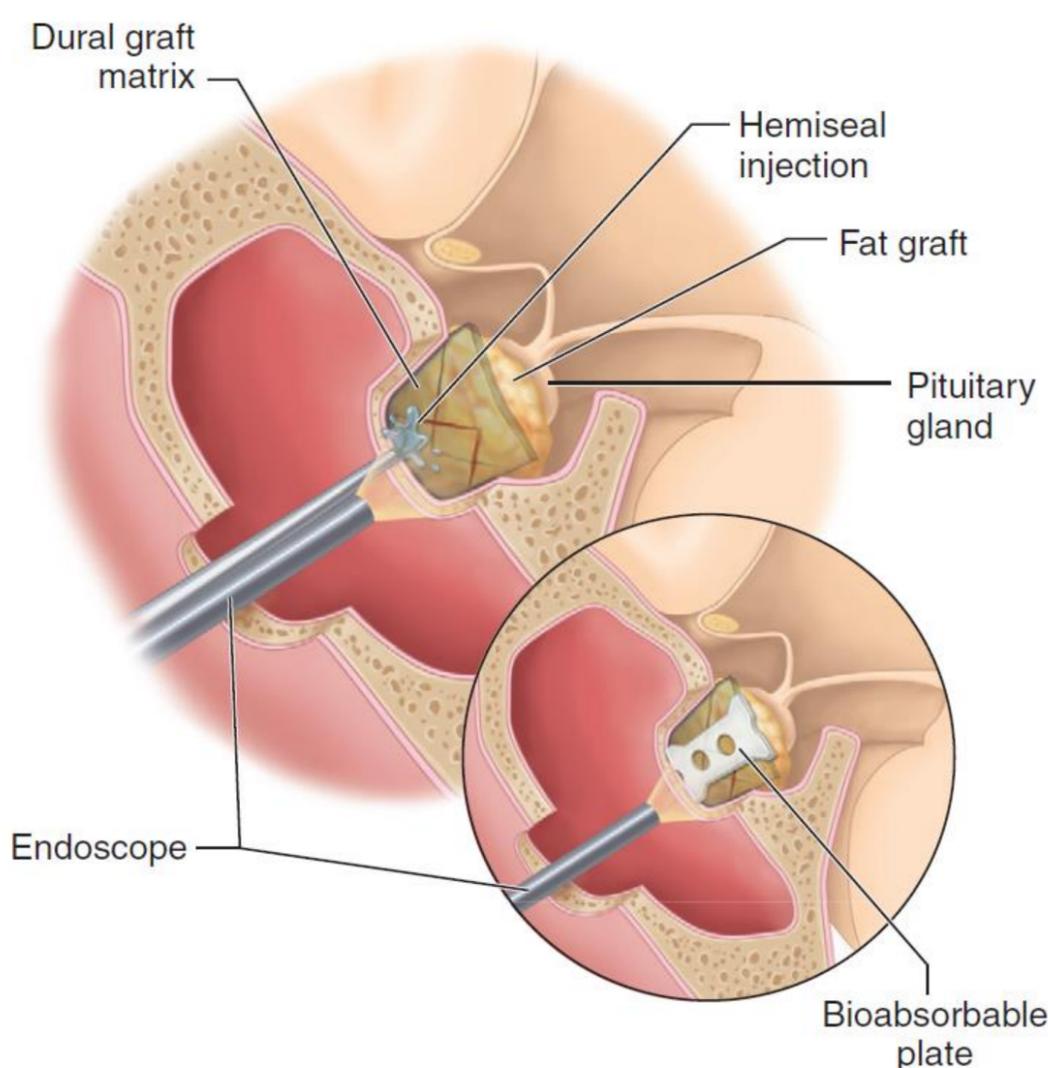


- for **high CSF flow risk patients** (e.g. high BMI) use multilayer closure: inlay – Duraform, Duragen, acellular dermal matrix; onlay – fascia lata, acellular dermal matrix, fat
- **Dr. Broaddus** technique: **DuraGen** to cover sellar floor → **bone** → another layer of **DuraGen** → **DuraSeal** spray.
- remove microscope.
- nasal mucosa falls into place when retractor is removed
- gingiva is closed using interrupted inverted 3-0 or 4-0 chromic gut or Vicryl suture with meticulous attention to align labial frenulum.
- **Meroceal packs** (with removed inner tubes and lubricated with bacitracin ointment) are placed in both nasal passages to maintain midline nasal septum (so direction of insertion is along hard palate and not towards sphenoid sinus) + avoid septal hematoma; packs are inflated with some saline spray; strings from packs are secured to patient's face using Mastisol and Steri-Strips; “pituitary” mask may be placed on patient’s face to contain secretions;

ENT likes **Doyle splints** – suture with Prolene to septum (through-and-through) – keeps septal mucosa apposed.

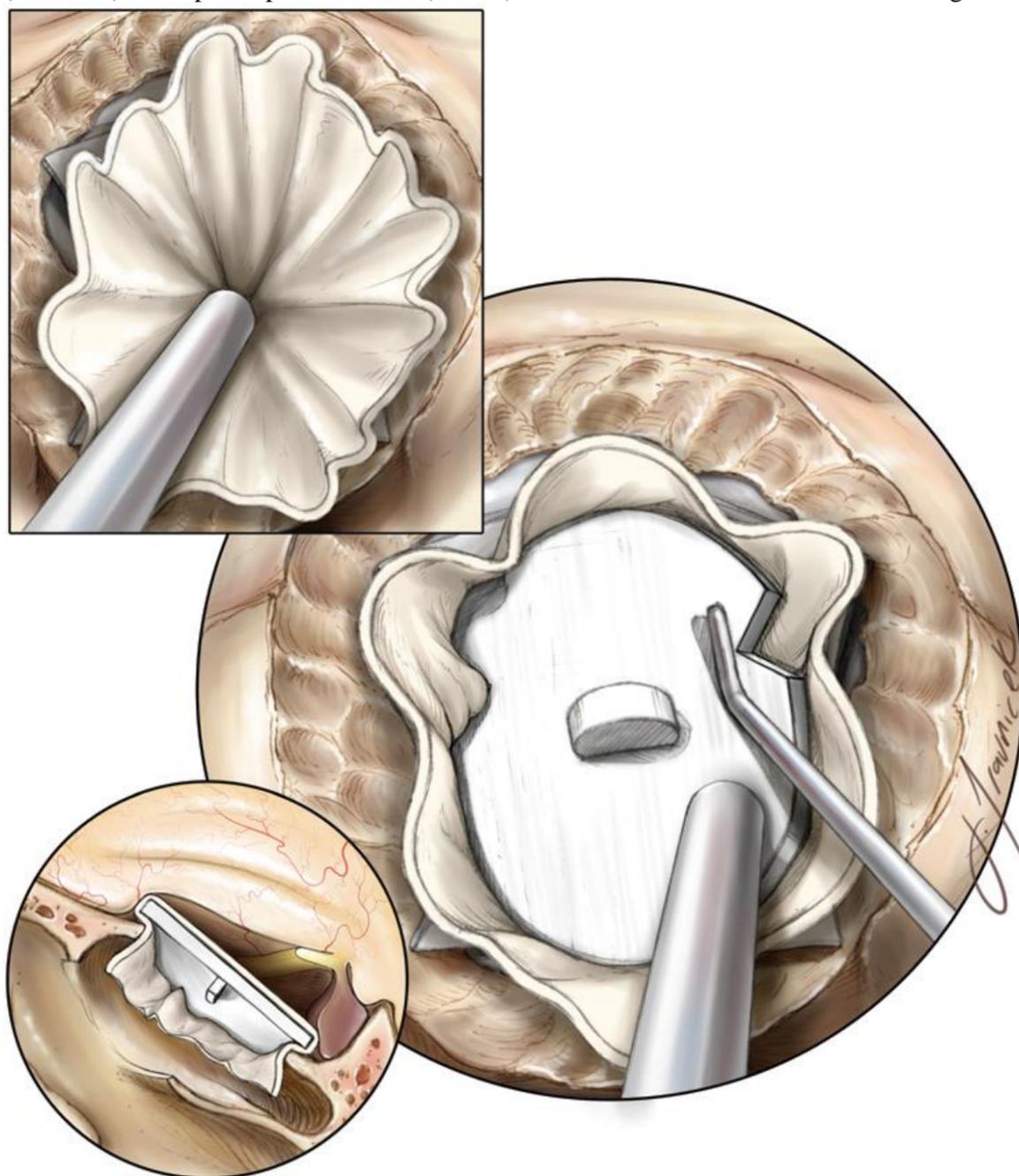
- **orogastric tube** is used to decompress the stomach and suction out the oropharynx

Guidelines on the Management of Patients with Nonfunctioning Pituitary Adenomas (CNS 2016): **insufficient evidence** to recommend specific **dural closure techniques**.



Source of picture: R. Jandial "Core Techniques in Operative Neurosurgery: Expert Consult - Online and Print", 1st ed (2011), Saunders; ISBN-13: 978-1437709070 >>

Reconstruction of large defects - gasket closure technique with tissue (**dural substitute** or **fascia lata**) that is circumferentially at least 1 cm larger than the bony defect is used. This layer of tissue is countersunk and held in place by a Porex rigid implant (Stryker) cut to the appropriate size; nasoseptal flap is placed over the gasket seal; the lateral edges of the flap should extend beyond the lateral edges of the fascia lata layer; flap is then covered with tissue sealant, either fibrin glue or DuraSeal (Covidien) to keep it in place. Floseal (Baxter) is then used to control mucosal bleeding:



Reproduced from Aaron A. Cohen-Gadol: The Neurosurgical Atlas.

POSTOPERATIVE

→ see p. Onc26 >>

ENDOSCOPIC TRANSNASAL (s. ENDONASAL) approach

- minimal access method done by endoscopic rhinologist for exposing midline skull base
<http://www.neurosurgicalatlas.com/grand-rounds/endoscopic-transnasal-surgery-personal-perspectives>

INDICATIONS

- broadened indications for transsphenoidal approach:

- 1) meningiomas of planum sphenoidale / tuberculum sellae / olfactory groove
- 2) medial cavernous sinus, pterygoid bone, juvenile nasal angiofibromas arising from pterygopalatine fossa
- 3) infrasellar clivus (e.g. chordomas).
- 4) encephaloceles, meningoencephaloceles, and other midline skull base defects prone to CSF leakage can be repaired through endonasal endoscopic approaches, avoiding craniotomy.
- 5) large tumors that cannot be completely removed with endoscope are not always contraindications to this approach (endoscopic approach helps to biopsy and may augment secondary cranial approach with internal decompression or staged resection).

CONTRAINDICATIONS

1. Pathology extending **laterally over orbits** or **lateral and posterior to carotid arteries*** - difficult to access, even when using extended endonasal approaches.
* availability of interventional neuroradiologist is crucial in preparation for endoscopic surgery around carotid artery
2. Lesions extending **into or posterior to frontal sinus** - difficult to reach even with angled scopes; also, nasoseptal flap may not reach this far anteriorly, and skull base closure may be challenging.
3. **Invasion of cavernous sinus** is not absolute contraindication but requires careful preoperative evaluation of surgical goals.

TECHNIQUE

- topical decongestion with Neo-Syneprine soaked pledgets
- 0° endoscope (some experts recommend 30-40° scope)
- may use endoscope holder.
- 1% lidocaine with 1:100,000 epinephrine solution injected into the bilateral middle turbinates and head of the superior turbinates.
- Frazier tip suction to clear out secretions from the nasal cavity.
- middle turbinate lateralized using a Freer.
- posterior attachment of the middle turbinate is used as a landmark to localize the sphenoid sinus.
- through-cut forceps used to resect inferior aspect of the superior turbinate - visualization of the sphenoid os which is entered with the Frazier tipped suction (or suction Bovie) and enlarged using the sphenoid (mushroom) punch medially and inferiorly.
- once bilateral sphenoidotomies are performed, Cottle is used to make a posterior septal incision, and the Blakesley and through-cut forceps are used to perform a posterior septectomy (fracture vomer).
- Jansen-Middleton rongeurs used to help take down the inner sinus septum
- Kerrison gently used to resect area of bone directly overlying the tumor.
- resection of mass. [see below >>](#)

Endonasal anatomy as seen through an endoscope:

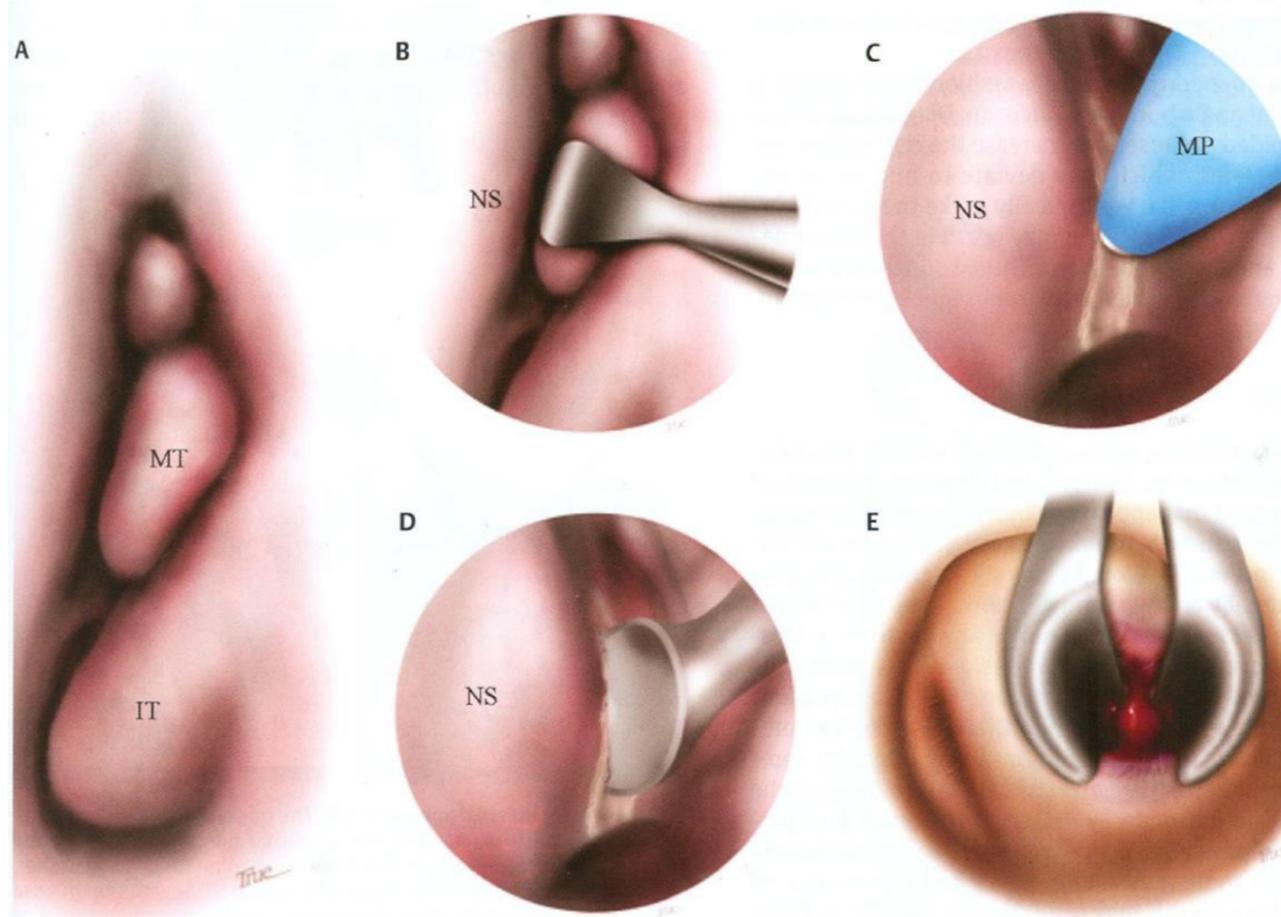
IT, inferior turbinate; MP, suction monopolar; MT, middle turbinate; NS, nasal septum

(A) The endoscope is passed through the patient's left nares and slowly advanced between the septum medially and the middle turbinate laterally.

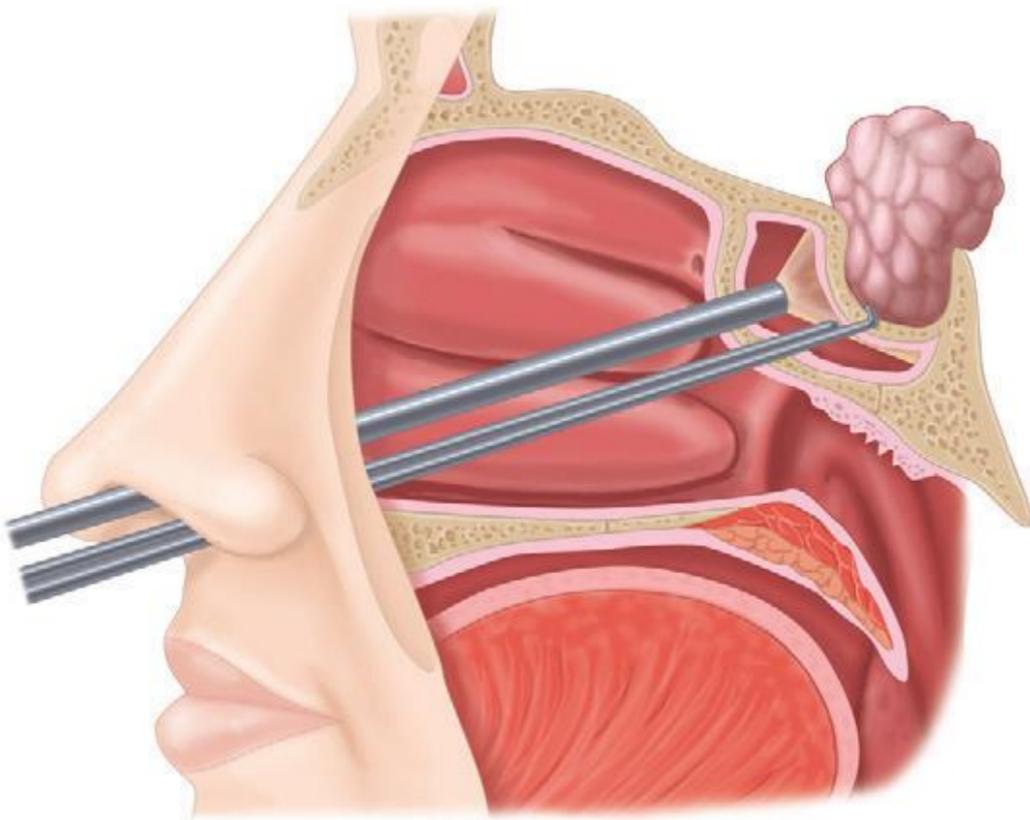
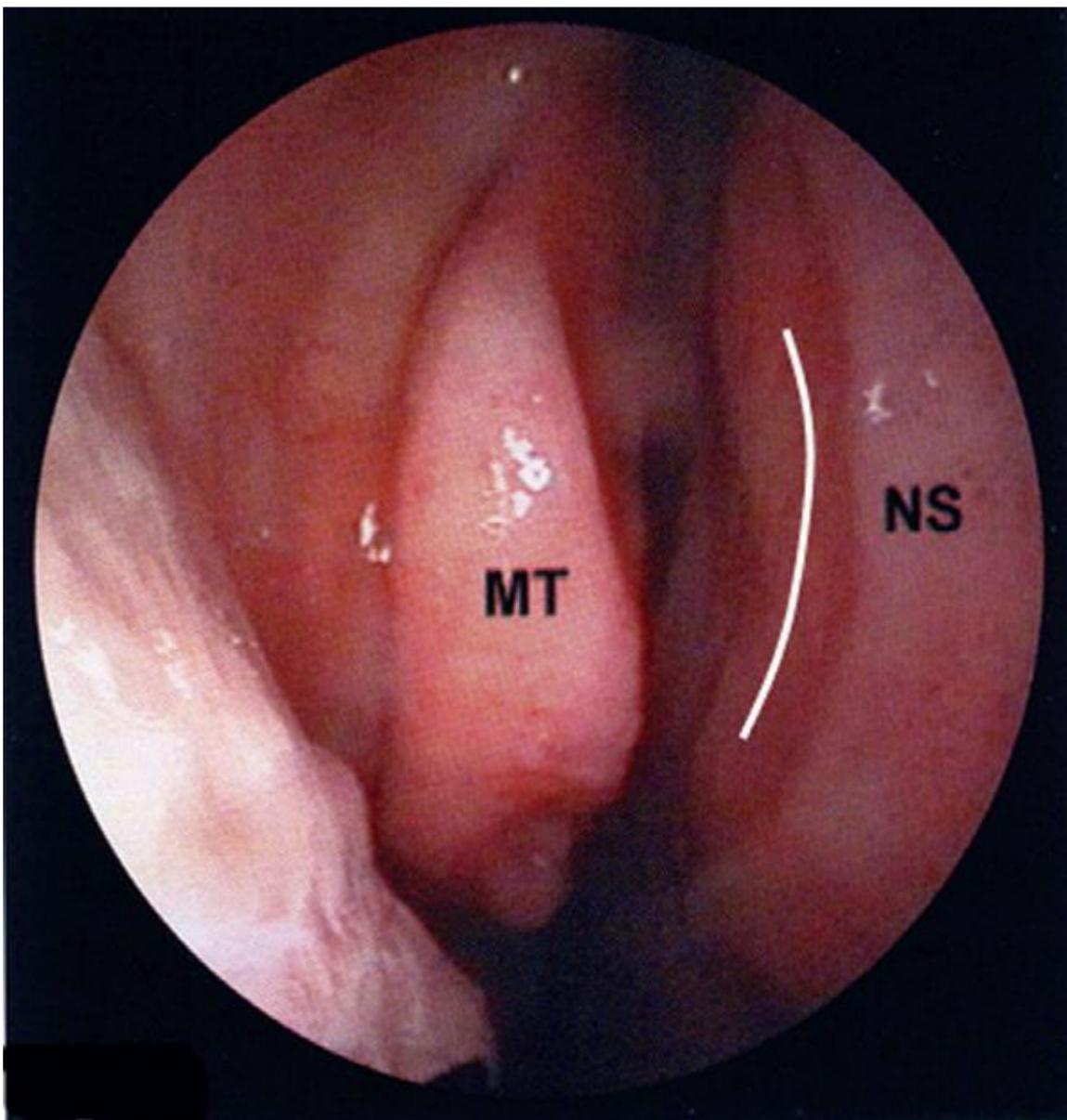
(B) As the endoscope is advanced, the flat end of a Penfield Dissector no. 1 can be used to push the middle turbinate laterally.

(C) The mucosa over the sphenoid sinus is coagulated using a suction-monopolar and (D) the posterior aspect of the nasal septum is fractured from the vomer using the sharp end of a Penfield-one.

(E) A narrow speculum is then advanced under endoscopic guidance to the sphenoid face and gently opened.



Linear incision is made in the mucosa overlying the posterior septum, and the septum is fractured and deviated to the opposite side with the use of a No. 2 Penfield dissector:



Source of pictures: R. Jandial "Core Techniques in Operative Neurosurgery: Expert Consult - Online and Print", 1st ed (2011), Saunders; ISBN-13: 978-1437709070 >>

Closure

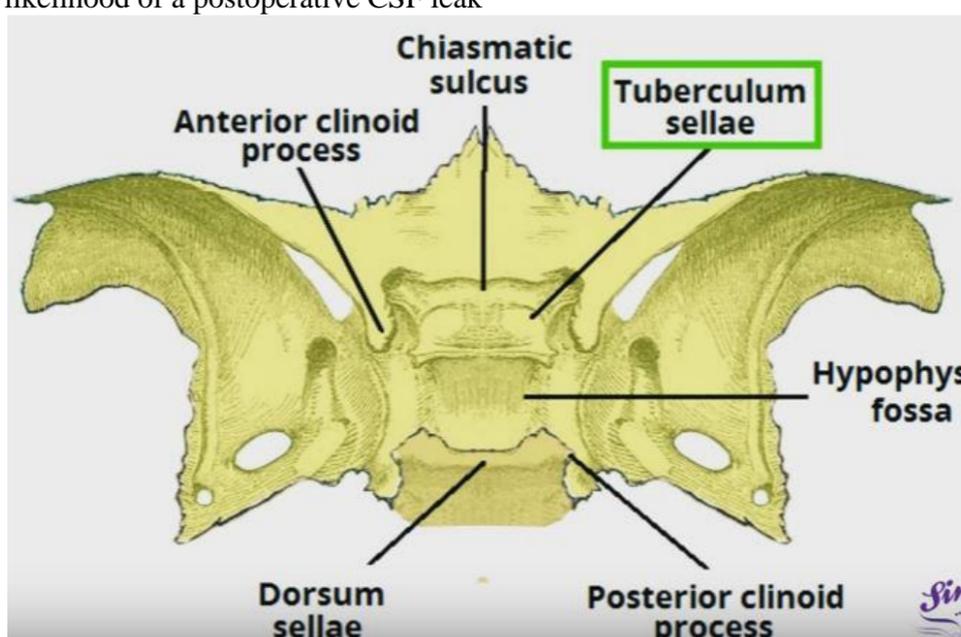
- defect filled with DuraSeal*, followed by a graft middle turbinate / abdominal fat graft, followed by additional DuraSeal and Gelfoam. *some experts do not use it
- after the nasal speculum is removed, the middle turbinate and the nasal septum are realigned into normal anatomical orientation - insertion of a lubricated fifth digit into the contralateral nares is often sufficient to check for septal alignment.
- 8 cm Merocel packs placed in bilateral nasal cavities and taped to the patient's cheek using Steri-Strips; some experts do not use nasal packing.

Blakesley nasal forceps:



TUMOR REMOVAL

- sellar floor inspected for tumor penetrations.
- sella is opened using **chisel** → removed laterally to cavernous sinus area using **2 mm Kerrison / Stryker Sonopet drill**.
- opening should not extend to the chiasmatic sulcus or tuberculum sellae because this can increase the likelihood of a postoperative CSF leak



DURA OPENING

- dura is cauterized using **suction Bovie cautery** and opened using # 11 blade (X or + -shaped incision).
N.B. use **navigation** and **Doppler** to check for carotids!
N.B. use **25G needle** puncture before using # 11 blade!
- some experts warn - **diagonal incisions should be avoided** because they increase the risk of injury to the carotid arteries (esp. at upper aspect of sella); thus, **make the vertical incision first** (horizontal incision may result in the tumor decompression and descent of the arachnoid superiorly, which may be inadvertently opened with a subsequent vertical cut).

TUMOR DISSECTION AND DEBULKING

Microadenomas:

- microadenomas that are not present on the surface of the pituitary require a systemic search through seemingly normal appearing gland: transverse incision is made in the gland, and blunt dissection is then performed around the normal-appearing tissue to search for the tumor.

Three types of dissection:

PSEUDOCAPSULE – tumor squeezed normal collagen reticulum of pituitary gland;
PSEUDOCAPSULE is very tough – can retract on it during dissection

1. **EXTRA-CAPSULAR** – avoid it as you are doing hypophysectomy of normal gland!
2. **INTRA-CAPSULAR** – traditional way when tumor is removed in piecemeal fashion using various **ring curettes** and **pituitary forceps** – messy, leaving tumor behind.
3. **PSEUDO-CAPSULAR** – dissecting along PSEUDOCAPSULE plane – removing tumor en masse;
 - possible for **microadenomas** and **macroadenomas** (may debulk center first); not possible for tumors **invading cavernous sinus**
Resection of pituitary macroadenomas via the pseudocapsule along the posterior tumor margin: a cohort study and technical note. Davis G Taylor, John A Jane, Edward H Oldfield. Journal of Neurosurgery 2017 August 18, : 1-7
 - no difference in DI rates.
 - need very wide exposure – must see “4 blues” (both cavernous sinuses, both intercavernous sinuses).
 - find normal gland then follow where it interfaces with tumor pseudocapsule
 - open dura carefully – do not disturb anterior normal gland (always there in front of tumor).
 - find plane with Rhoton # 3 dissector – goes easy inside capsule plane (may debulk tumor if it is too big).
 - dissect carefully from diaphragm or it will lead to CSF leak.

Macroadenomas:

- **sella is emptied** with ring curettes – start at **inferior** sella, then go **lateral** (do not pull if curette catches on something – may be carotid!; may use curved suction tip), **last is center of tumor** – this way making superior tumor portions to sink down and diaphragm shows up when tumor is removed (otherwise diaphragm would be on the way to reach tumor).
 - use **larger curettes** at the interface between the tumor and the sellar wall and along its deep parts because it causes less pressure to the wall compared with a small curette; hence, there is less chance to tear the wall by using a larger curette.
 - adherent tumor fragments should not be pulled down because this may result in stalk traction and irreversible diabetes insipidus.
 - may flood sella with saline and insert angled endoscope for inspection.
- if diaphragma sellae starts sinking into the field → drain 50 mL of CSF from lumbar drain - diaphragma then recedes.
N.B. avoid **CSF leak** - ↑risk of meningitis.
 - tumor may remain inside folds of patulous diaphragm.
 - central diaphragma fold is indicator of stalk.
 - **100% alcohol soaked pledgets** may be placed into sella cavity (when arachnoid remains intact) for a few minutes to achieve additional tumoricidal effect (but only if no CSF leak).
 - no reason to send for frozen pathology (but **Dr. Broaddus** does)!

BLEEDING CONTROL

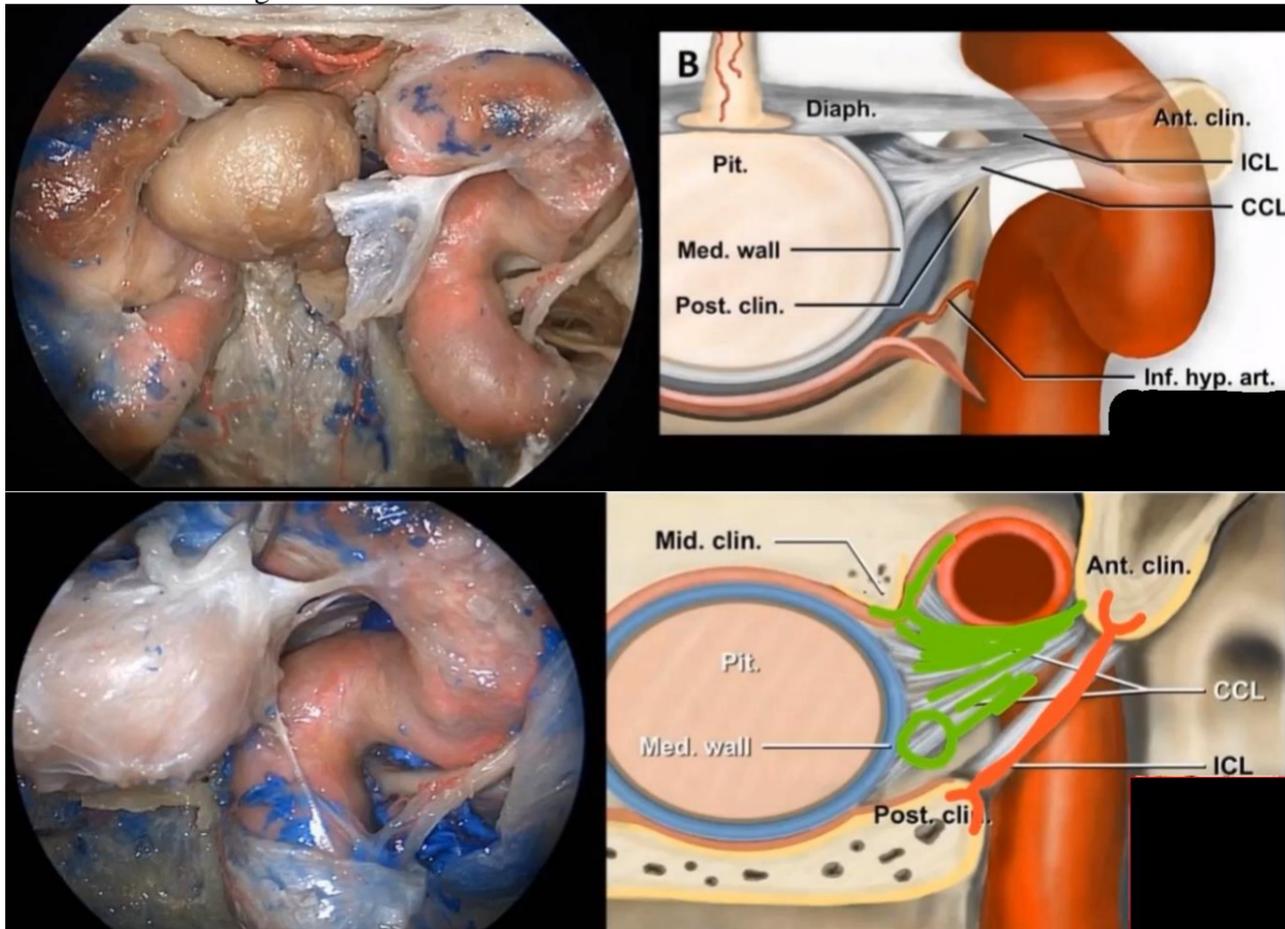
- most bleedings are venous – keep head above heart level.
- consider TXA

CAVERNOUS SINUS INVASION

- almost impossible to remove (causes CN deficits – mostly permanent), however, master experts do it safely.
- if tumor soft – remove as much tumor in cavernous sinus as can be easily removed; if tumor firm – it's OK to leave some tumor in cavernous sinus to avoid cranial neuropathy (residual can be treated with SRS if it regrows).

CCL – carotic-clinoid ligament

ICL – interclinoid ligament



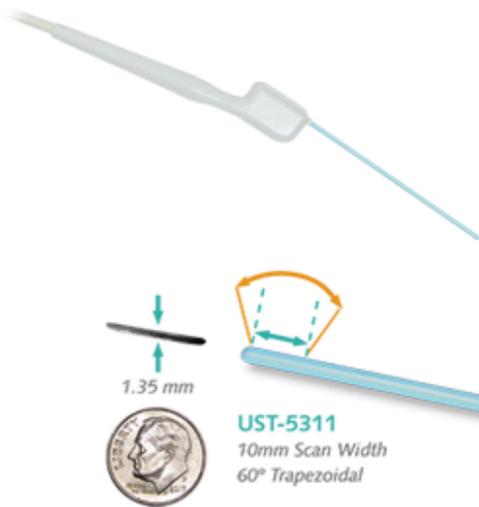
GIANT PITUITARY ADENOMAS

- look at the *smoothness of tumor dome* – if smooth, likely diaphragm is intact and TSR will be successful.
- wide sella opening* is very important – CS to CS (use Kerrison with footplate between bone and dura – will help to stay extradural and expose vasculature without risk).
*allows tumor to fall down – “If you want roof of house to fall, destroy walls”
- navigated suction is helpful.

STRATEGIES FOR SUPRASellar EXTENSIONS

A. Visualizing superior aspect of tumor:

- intraop MRI
- draining 20 mL of CSF from lumbar drain → insufflating subarachnoid space with 20 mL of air via lumbar drain → fluoroscopy– one can see air at the top of tumor
- 30 and 45 degree endoscopes
- 90 degree US probe, e.g. UST-5311 by Hitachi Aloka:



UST-5311

Pituitary Guidance Transducer

Exclusive 10mm side-fire linear array transducer with 2.87mm diameter is ideal for real-time visualization through and behind structures and instant, scalable definition of anatomy and vascularity including the ability to delineate and define tumor margins.

- Exceptional near and far field resolution
- Trapezoidal imaging further increases field of view
- Instant, scalable definition of anatomy and vascularity
- Instant feedback on extent of resection

Main Specifications:

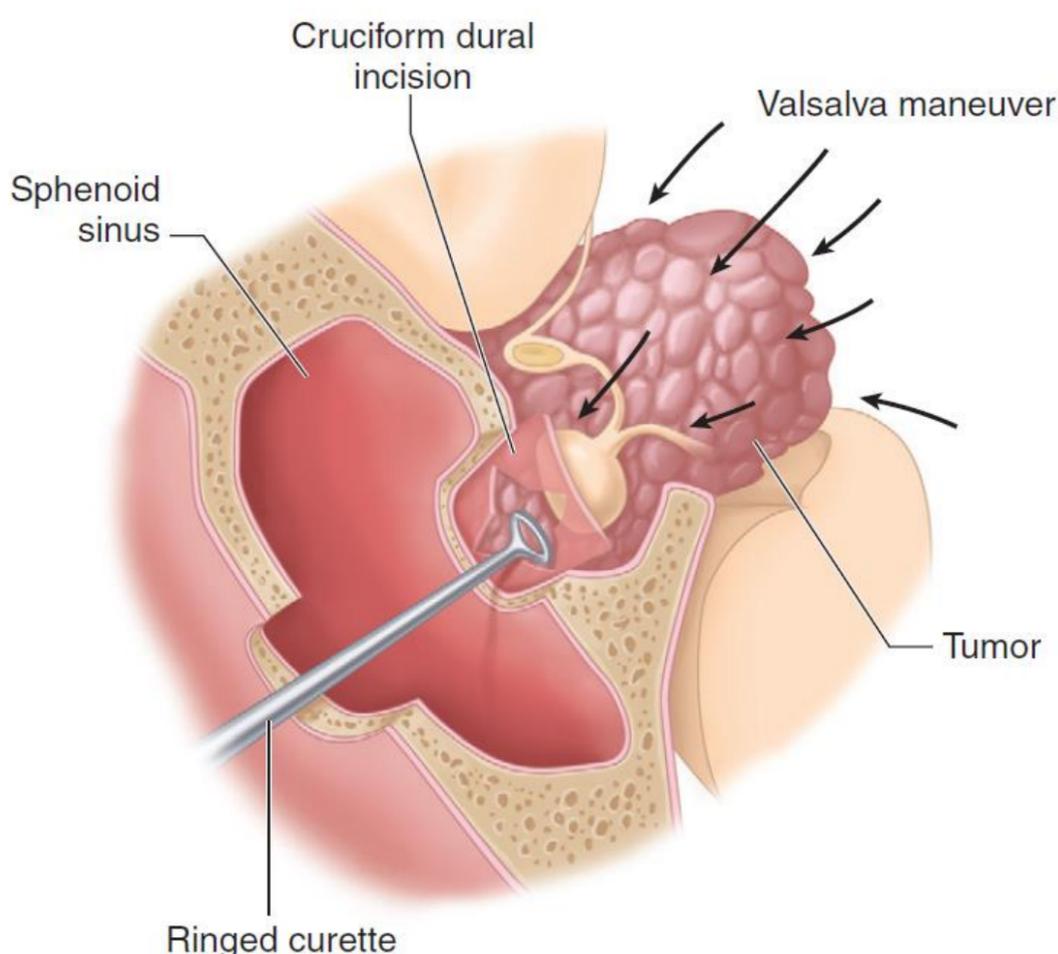
- Array Type: Linear
- Frequency Range: 17 - 4 MHz
- Scan Width: 10mm, 60° Trapezoidal

B. Pushing tumor down:

- Valsalva** (does not work if there is CSF leak)
- insufflating** subarachnoid space with 1-3 mL preservative-free saline **via lumbar drain**.
- removal of more of superior bone** (beware optic chiasm and nerves – use navigation with segmented bone and optic apparatus).
- ask anesthesia to **compress bilateral jugulars** for 30 seconds = “Valsalva on steroids”

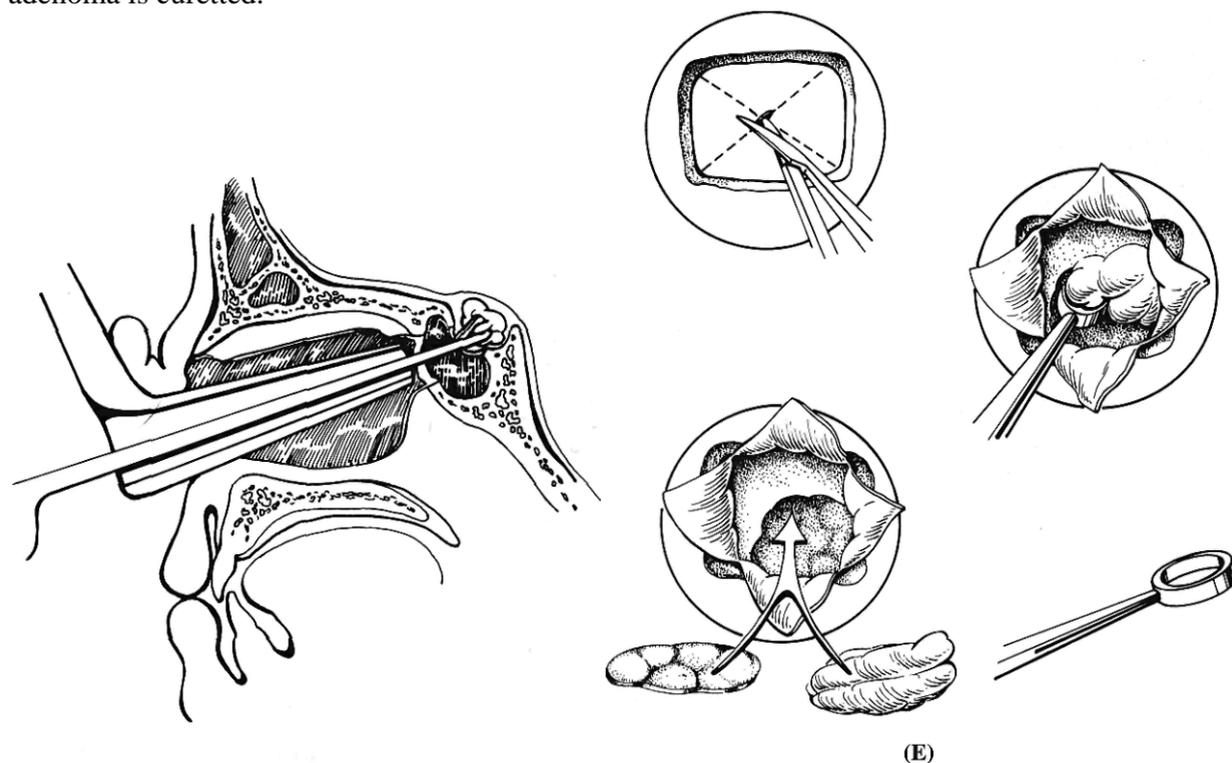
Guidelines on the Management of Patients with Nonfunctioning Pituitary Adenomas (CNS 2016)

There is **insufficient evidence** to recommend the use of **intrathecal saline or air** for suprasellar tumor delivery to augment NFPA resection.



Source of picture: R. Jandial "Core Techniques in Operative Neurosurgery: Expert Consult - Online and Print", 1st ed (2011), Saunders; ISBN-13: 978-1437709070 >>

Microadenomas - frequently necessary to make *vertical pituitary incisions* to search for adenoma - adenoma is curetted.



Source of picture: Marshall B. Allen, Ross H. Miller "Essentials of Neurosurgery: a guide to clinical practice", 1995; McGraw-Hill, Inc.; ISBN-13: 978-0070011168 >>

CHEMONAVIGATION

OTL38 - fluorescent dye of two parts: **vitamin B9 s. folic acid** (a necessary ingredient for cell growth), and a **near infrared glowing dye**.

- as tumors try to grow and proliferate, they **overexpress folate receptors**.
- pituitary tumors can overexpress folate receptors > 20 times above the level of the normal pituitary gland in some cases - dye binds to these receptors and allows to identify tumors.

iMRI

Guidelines on the Management of Patients with Nonfunctioning Pituitary Adenomas (CNS 2016)

Level III Recommendation: **intraoperative MRI** can improve gross total resection, but its use is associated with an increased false-positive rate and is thus **not recommended**.

- although intraoperative MRI helps improve immediate overall gross total resection of nonfunctioning pituitary adenomas, intraoperative MRI for estimating residual tumor is not recommended due to a reported variable false-positive rate. This false-positive rate may contribute to the higher rate of gross total resection occurring with intraoperative MRI (but at the cost of removing normal tissue) and underscores the importance of incorporating surgical experience in the interpretation of intraoperative MR imaging for surgical decision-making.

COMPLICATIONS (INTRAOP)

CAROTID INJURY

N.B. brisk bleeding can occur with a breach in **McConnell's capsular arteries**, which arise from the cavernous carotid that often supply vascularized sellar tumors. see p. A205 >>

Treatment:

- 1) **large bore suction** and **call for blood**
- 2) anesthesiologist may **compress carotid in the neck** (helps to slow down bleed rate); at extreme – **ADENOSINE** bolus IV to allow for carotid inspection and targeted patching.
- 3) may try to **bipolar** if it is a small wall laceration or side branch avulsion.
- 4) **pack** tightly (Gelfoam wrapped in Surgicel; best thromboplastic material – muscle*, then fat; shredded Teflon / cotton / muslin gauze for smaller lacerations) – often times, there is no need for high pressure.
 - *some experts of endoscopic skull base surgery have thigh prepped in case muscle plug will need to be harvested; others – cut the piece of tongue and use as a plug (last resort, but tongue is right there)
- 5) keep **intubated** with tight **BP control** → **CTA**
 - N.B. watch for delayed **pseudoaneurysm** formation! – presents with profuse nose bleed; treatment: coiling + pipeline stent.
- 6) if still bleeding → **angiography**:
 - a) **ICA coiling** (even after sacrificing ICA patient may wake up asymptomatic; if TIAs – may consider ECA-ICA bypass)
 - Look at CTA (if available) – if **circle of Willis is incomplete** (cannot expect carotid cross-filing) – cannot sacrifice carotid!
 - b) **covered ICA stent**: Jostent – very stiff and difficult to navigate; no need for heparin but load with Aspirin and Plavix in OR through NG tube; if angio shows in-stent thrombosis –

give glycoprotein IIb/IIIa receptor blocker (e.g. ReoPro) and repeat angio every 10 minutes until clot resolved.

Prevention:

- 1) **Review imaging** - MRI with contrast, CT (sometimes intrasphenoidal septation leads to carotid canal)
(Labib et al. Neurosurg 2013 – ICA projection into sphenoid sinus)
- 2) **Neuronavigation** – accuracy too low (other experts say that navigation is all you need).
- 3) **Doppler probe** then cut dura away from carotid; may also try to aspirate with #25 needle before cutting dura.
- 4) **ICG angiography** (microscope or endoscope with filter) – shows major vessels; tumor lights up later (craniopharyngiomas remain “cold”).
- 5) Chondroid tumors have highest carotid injury rate – may do **preop carotid occlusion test**.

COMPLICATIONS (POSTOP)

- see p. Onc26 >>