Endoscopic Pituitary Resection

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Objectives

- History of pituitary surgery
- Sphenoid embryology and anatomy
- Sellar/Parasellar Anatomy
- Pituitary pathology
- Diagnostic workup
- Indications for surgery
- Surgical Approaches
- Sellar Reconstruction
- Outcomes in endoscopic pituitary resection
History

- 1907 – Schloffer performs first pituitary surgery via lateral rhinotomy

- 1909 – Hirsch uses submucosal resection of septum and endonasal approach

- 1910 – Halstead introduces gingibovuccal sulcus incision for sublabial trans-septal approach

- 1914 – Cushing combines sublabial incision with submucous septal approach, preserving nasal function, no external scar

- 1960’s – Guiot uses operating microscope and intraoperative fluoroscopy. Using a trans-septal approach either sublabial or via open rhinoplasty remains the preferred approach at many centers.

http://www.ghorayeb.com/TransSphenoidMRI.html
History

- 1970’s – Development of endoscopy
- 1992 – Jankowski et al. performed endoscopic transnasal transsphenoidal approach, then microscope
- 1996 – Jho et al. describe entirely endoscopic transnasal transsphenoidal approach

Sphenoid Sinus Embryology

- Sphenoid sinus is an *extension* of the ethmoid sinuses into the sphenoid bone.
- Evaginations of ethmoid sinuses into sphenoid bone at 4th month of fetal development.
- Growth begins at 3 years of age.
- Fully pneumatized by 7 years of age.
- Peak size reached at 20 years of age.
Sphenoid Sinus Anatomy

- Adult size ranges from 14 x 14 x 12mm to 20 x 23 x 17mm
- Adult sphenoid sinus volume average is 7.4cm$^3$

- Intersinus septum – sagitally oriented divider
  - Fully vertical in 25%
  - Symmetric paired sinuses in 27%
  - In midline anteriorly then deviates to one side posteriorly in 43%
Sphenoid Pneumatization:

- Sellar – 86%
  - Well pneumatized sphenoid body with full indentation of the sella into the sinus

- Presellar – 11%
  - Moderate pneumatization with no indentation of the sella

- Conchal - 3%
  - Minimal pneumatization

**FIGURE 1.** Sagittal views of the three major classifications of the sphenoid sinus: sellar (A); presellar (B); conchal (C).
Intrasphenoidal anatomy

- Sella Turcica – central roof of sinus overlying the pituitary
  - Avg bone thickness 0.4 mm
  - Avg distance from ostium is 14-17mm

- Planum Sphenoidale – roof of sinus anterior to sella
  - Above this lies dura of anterior fossa

- Tuberculum recess – junction of planum and sella

Operative Otolaryngology. Ch 103.
Question

- How many degrees off the nasal floor is the sphenoid sinus ostium?
- How many centimeters from the nasal spine?
- Who is credited with this often pimped fact?
Question

- How many degrees off the nasal floor is the sphenoid sinus ostium?
  - 30 degrees

- How many centimeters from the nasal spine?

- Who is credited with this often pimped fact?
Question

- How many degrees off the nasal floor is the sphenoid sinus ostium?
  - 30 degrees

- How many centimeters from the nasal spine?
  - 7cm

- Who is credited with this often pimped fact?
Question

- Who is credited with this often pimped fact?
  - Davis, Templer, and Parsons
Question

The Onodi cell is

- A. A rare cell found in the middle turbinate
- B. The most lateral cell of the anterior ethmoid cells
- C. The most posterior of the posterior ethmoid cells
- D. Is the cell that invaginates anteriorly into the anterior ethmoid cells
- E. Is the cell that indents the inferior wall of the frontal sinus
Question

- C. The Onodi cell is the most posterior cell of the posterior ethmoid sinuses that is lateral to and well behind the anterior face of the sphenoid sinus

- ONodi – Optic Nerve
Surface Landmarks

Fig. 46.2  Endoscopic view of bilateral sphenoid sinuses after bilateral sphenoidotomy and posterior septectomy. The blue dotted line demarcates the area of sellar (S) bone removal for intrasellar tumors; the green dotted line demarcates additional bone that needs to be removed from the planum sphenoidale (PS) for suprasellar approaches. Depending on the degree of sphenoid pneumatization, the optic canal (OC), post-communicating recess (OCR), internal carotid artery (ICA), and clival recess (CR) may present as surface landmarks within the sphenoid sinus. (Used with permission from Jackler RK. Atlas of Skull Base Surgery.)

median septum divides the sphenoidal sinus into two compartments. Removal of the intersinus septum. SF, sellar floor; CP, carotid protuberance; carotid recess; SM, sphenoidal mucosa; asterisk, median sphenoid septum.
Optic Nerves

- Visible prominences on the lateral sphenoid wall bilaterally
- Radiographically dehiscent in 23%
- Clinically dehiscent very infrequently
Internal Carotid Artery

- Carotid prominence just lateral to sella turcica
- Bony covering typically thinner than the sella
- ICA bony dehiscence ranges from 0-23%
- Prone to injury at tuberculum sella d/t short distance between and immobility

Cavallo LM 2012
Figure 103-5  The left cavernous segment of the internal carotid artery (ICA) is dehiscent and susceptible to injury. A lateral sphenoid septation (S) attaches to the carotid canal.
Quiz
Quiz
Quiz

- Anterior cerebral artery
- Cerebral part
- Internal carotid artery
- Cavernous part
- Cavernous sinus
- Oculomotor nerve (III)
- Trochlear nerve (IV)
- Abducent nerve; Abducens nerve (VI)
- Ophthalmic nerve; Ophthalmic division [Va; V1]
- Maxillary nerve; Maxillary division [Vb; V2]

Illustration: A. Micheau - MD
Figure 175-4. Oblique view of the right lateral nasal wall and sphenoid sinus region after removal of the nasal septum and the anterior wall of the sphenoid sinus: 1, ethmoid sinus; 2, sphenoid ostia; 3, sphenoid sinus; 4, anterior sella wall; 5, internal carotid artery; 6, trigeminal nerve; 7, superior arch of the choana.
Figure 175-8. Endoscopic view of the posterior wall of the sphenoid sinus: 1, prominence of the internal carotid arteries; 2, clivus; 3, anterior sellar wall; 4, optic nerves; 5, intercavernous sinus.
Figure 175-6. Frontal view of the central skull base after removal of the walls of the sphenoid sinus and the dura: 1, pituitary gland; 2, internal carotid artery; 3, optic nerves; 4, ophthalmic arteries; 5, inferior hypophyseal arteries; 6, sympathetic nerves. (Courtesy of Drs. I. Inoue and A. Rhoton.)
Retroclival Anatomy

Figure 175-9. Endoscopic view of the posterior fossa after the removal of the posterior wall of sphenoid sinus and upper clivus. 1, basilar artery; 2, internal carotid arteries; 3, optic nerves and chiasm; 4, pituitary gland and pituitary stalk; 5, brainstem.
Shift gears

- Pituitary pathology
- Diagnostic workup
- Indications for surgery
Pituitary Tumors

- Represent 10-15% of intracranial neoplasms, up to 90% of sellar masses
- Pituitary adenomas present in 3rd and 4th decade
- Arise from adenohypophyseal cells in anterior pituitary.
- Histologically benign but can still enlarge and invade surrounding structures
- Carcinomas RARE: distant metastasis is the sole diagnostic criteria for malignancy
- Secreting vs Nonsecreting
  - Non secreting tumors present due to mass effect
Diagnostic Workup

- MRI, Labs

Table 46.1 Laboratory Screening for Patients with Pituitary Adenoma

<table>
<thead>
<tr>
<th>Test</th>
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<tr>
<td>Serum prolactin</td>
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<tr>
<td>Thyroid function tests</td>
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<tr>
<td>• Thyroid stimulating hormone</td>
</tr>
<tr>
<td>• Free thyroxine</td>
</tr>
<tr>
<td>Serum gonadotropins</td>
</tr>
<tr>
<td>• Men: Testosterone</td>
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<tr>
<td>• Women: Estradiol + progesterone</td>
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<td>Insulin-like growth factor (IGF-1)</td>
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If considering acromegaly: oral glucose tolerance test (OGTT) with growth hormone obtained at 0, 30, and 60 minutes

If considering Cushing syndrome: 24-hour urinary free cortisol, dexamethasone (1.0 mg) suppression test

Imaging

- MRI is modality of choice
- “Snowman” or dumbbell appearance with homogenous enhancement of solid lesion.

- T1
  - Adenomas are isointense to the normal pituitary gland and to the gray matter

- T1 with gadolinium
  - 70-90% of adenomas are HYPOintense compared to the intensely enhancing normal pituitary gland

- Dynamic MRI – sequential MRI enhancement patterns
  - Helps identify microadenomas which are hypointense on early phase with contrast
Pituitary Tumors

- Microadenoma
  - <1.0 cm
  - Generally enclosed, less frequently invasive
  - Typically diagnosed due to hormone hypersecretion or incidentally when non functional
  - Normal pituitary seen on MRI with contrast
Pituitary Tumors

- Macroadenoma
  - >1.0 cm
  - Enclosed, invasive, or expanding
  - Diagnosed d/t hormone hyper/hyposecretion or mass effect, or incidentally
  - Normal pituitary typically not visible on imaging
  - Snowman/dumb bell
Cavernous Sinus Extension

- 25 pituitary adenomas
- Junction of Grade 2/3 – invasion of CS
Secreting Pituitary Tumors

- Present with endocrine manifestations of the hormone secreted.
  - In order of frequency:
    - Prolactinomas
    - Growth hormone
    - Adrenocorticotropic hormone
    - Follicle-stimulating hormone
    - Leuteinizing hormone
Prolactinomas

- The most prevalent pituitary tumor
- Women - galactorrhea and amenorrhea. Men present with decreased libido and hypogonadism.

- Surgical control for macroadenomas is poor
  - Surgical remission
    - Microadenomas – 75%
    - Macroadenomas – 34%
  - Recurrence
    - Microadenomas – 18%
    - Macroadenomas – 23%

- Respond well to dopamine agonist (bromocriptine, cabergoline)
  - Prolactin normalizes and tumor shrinkage in 80% of cases

Thus surgery is second line treatment

Gilliam et al. 2006
Acromegaly

- Growth hormone secreting adenoma
- Rare but disabling, 38-69 cases per million
- Gigantism if before adulthood
- Life expectancy reduced by 10 yrs due to cardiovascular
- Surgery is first-line therapy, rapid reduction GH/IGF-1
- Medically treated with somastostatin analogue – octreotide for large/invasive tumors
Cushing’s Disease

- Adrenocorticotropic Hormone-secreting microadenomas.
- Increased mortality rate
- Surgical resection is first line treatment
- Disease control in 60-80% of cases, <15% for macroadenomas

- Central obesity, muscle wasting, thin skin, hirsutism, purple striae.
- Psychological changes.
- Osteoporosis, hypertension, poor wound healing.
- Hyperglycemia, glycosuria, leukocytosis, lymphocytopenia, hypokalemia.
- Elevated serum cortisol and urinary free cortisol. Lack of normal suppression by dexamethasone.
Symptoms of Mass Effect

- More common in non-functional tumors

- Visual Symptoms
  - Optic chiasm compression – bitemporal hemianopsia
    - Increased susceptibility of nasally oriented optic nerve fibers to pressure compared to the temporal fibers.
  - Oculomotor palsy/paralysis
    - Uncommon of uncomplicated masses
    - Should raise suspicion for apoplexy or malignancy

- Third ventricle obstruction – hydrocephalus
- Pituitary compression – hypopituitarism, decreased libido
- Headache – etiology not completely understood
  - May improve, be unchanged, or even worsen with treatment
Apoplexy

- Acute hemorrhage or infarction of the pituitary gland often in the setting of pituitary adenoma
- Life threatening

- Sudden onset of:
  - Headache
  - Vomiting
  - Ocular paresis, reduced visual fields, or reduced acuity
  - Altered mental status
  - Hormonal dysfunction

- Treatment
  - Surgical decompression
  - Visual changes recover if surgery w/in 1 week
  - Endocrine changes unlikely to recover
Surgical Approaches

- Transnasal
- Transseptal
- Transseptal-Transnasal
- Transethmoid
Transnasal

- Resect superior turbinate
- +/- post portion of middle turb
- Seeker probe to ostia
- Micro-Kerrison punch to enlarge ostium inferiorly and medially
- Anterior wall, rostrum and intersinus septae are removed

- Video

Figure 175-13. Opening of the sphenoid sinus anterior wall by means of a micro-Kerrison punch through a direct transnasal approach (arrow on inset).

Cummings Ch 175.
Transseptal

Cummings Ch 175.
Transseptal

- Cummings Ch 175.
Transseptal

- Midline approach to sphenoid
  - Avoids structures of nasal cavity
  - Avoids lateral wall of sphenoid
    - ICA
    - Optic nerve

- Hemitransfixion at caudal septum
- Elevate mucoperichondrial flaps
- Dissarticulate osseocartilaginous junctions (superior intact)
- Remove posterior septum with JM
- Elevate mucosa from sphenoid face
- Self retaining speculum, chisel, microKerrisons to enlarge

Cummings Ch 175.
Transseptal

Cummings Ch 175.
Transseptal
Transseptal-Transnasal

- Killian incision
- Bilateral flaps
- Resect posterior septum
- Elevate unilateral SN flap
- Enter sphenoid as in transseptal approach

Advantages
- Two surgeon ability
- SN flap reconstruction
- Preserves contralateral mucosa
Transethmoid Access

- Advantages/utility
  - Disease process in or around ethmoids
    - CSF leak, inverted papilloma, schwannoma, meningocele, etc.
  - Uncinnnectomy, bulla, ant/post ethmoidectomy
  - Sphenoid ostium opened with probe, enlarge inferomedially

Cummings Ch 175.
Accessing the Pituitary

- Sphenoid opened widely, now what?
Accessing the Pituitary

- Sphenoid opened widely, now what?
- Transsellar Approach
- Parasellar Approach
- Transclival Approach
Transsellar Approach

- Through bite intersinus septae
- Identify landmarks
- Elevate mucoperisteum over sella and preserve for recon
- Diamond burr and microKerrison to remove bone from face of sella
  - Planum sphenoidale to Clivus
  - Carotid to carotid
- Incise dura
- Tumor resection

Getz AE 2012
Fig. 46.4 Careful removal of sellar bone reveals the dura, which is incised sharply to access the tumor. (Used with permission from Jackler RK. Atlas of Skull Base Surgery and Neurotology, 2nd ed. New York: Thieme; 2009: 163.)
Endoscopic transsphenoidal pituitary surgery

Christoph Hofstetter, MD, PhD, a Vijay K. Anand, MD, FACS, b
Theodore H. Schwartz, MD, FACS a, b

Figure 2  Removal of tuberculum sellae and planum sphenoidale to facilitate the resection of the suprasellar portion of the tumor. A, Sagittal preoperative contrast enhanced MRI reveals suprasellar extension of a pituitary macroadenoma. The green line, derived from the stereotactic navigation software, indicates the trajectory necessary to access the superior extend of the lesion and the amount of bone required to see over the top of the tumor. B, Intraoperative image following the removal of the posterior wall of the sphenoid sinus depicts the bulging dura over the floor and anterior face of the sella behind which lies the tumor. C, Removal of the tuberculum sellae and part of the planum sphenoidale prepares the surgical corridor for removal of the suprasellar part of the lesion. Note the change in consistency of the dura over the floor of the sella and the dura behind the tuberculum sellae and planum sphenoidale. D, Postoperative sagittal MRI demonstrates a complete resection of the tumor, the extent of the resected bone and the nasoseptal flap holding the fat graft in place. Note how the lip of bone at the floor of the sphenoid sinus and top of clivus can hinder the flap from draping onto the posterior wall of the sinus.
Tumor Dissection

Fig. 46.6 Extracapsular dissection around the right lateral aspect of tumor bordering on the cavernous sinus. (Used with permission from Jackler RK. Atlas of Skull Base Surgery and Neurotology, 2nd ed. New York: Thieme; 2009: 165.)
Sella Reconstruction

- If NO CSF leak
  - Re-drape mucoperiosteum of sphenoid then fibrin glue

- Mild/Mod CSF Leak
  - Fascia, fat, then mucoperiosteum and fibrin glue
  - May add acellular dermal graft +/- cartilage

- Large CSF Leak
  - Fascia, fat, septonasal flap, packing of sphenoid for 5-7 days

Lorenz RR 2003

Jackler RK 2009
Getz AE 2012
Nasoseptal flap

Cummings Ch 175.
Fig. 4. Endoscopic view of the posterior nasal cavity (A) with an artist's representation of the same view (B). Dashed lines mark the location of cuts for the posteriorly based nasal septal flap. IT, inferior turbinate; SO, sphenoid os; SPF, sphenopalatine fossa; ST, superior turbinate.
Nasoseptal Flap Technique.
Kassam et al 2008

All subsequent images depict reported technique

**FIGURE 1.** The nasoseptal flap incisions at the anterior nasal cavity. Two parallel incisions are joined by a vertical incision anterior to the inferior turbinate.
FIGURE 2. The nasoseptal flap incisions at the right posterior nasal cavity. Two parallel incisions (dashed lines), one following the maxillary crest and the other 1 to 2 cm inferior to the olfactory cleft, are extended to reach the lateral nasal wall. The inferior incision follows the free edge of the posterior septum and then crosses the posterior choana. The inferior incision may be designed to include the mucoperiosteum of the floor of the nose. The superior incision extends laterally to cross the rostrum of the sphenoid sinus at the level of its natural ostium. A large middle antrostomy and exposure of the terminal internal maxillary artery are illustrated. This is only necessary if the flap will be stored in the maxillary sinus so as to approach the clival and paraclival areas.

FIGURE 3. Elevation of the nasoseptal flap following a subperichondrial and subperiosteal plane.
FIGURE 4. A, the nasoseptal flap is mobilized posteriorly after a posterior septectomy. B, the nasoseptal flap is “stored” at the nasopharynx. C, the nasoseptal flap is “stored” inside the maxillary sinus.
**FIGURE 5.** The nasoseptal flap is shown covering a defect at the planum sphenoidale.
Nasoseptal flap to sella

Figure 103-13 A right septal mucosal flap (arrows denote margins) has been transposed to cover the defect in the skull base.
Surgical Repair cont’d

- After overlay placement…
  - Apply fibrin glue
  - Then absorbable nasal packing (GelFoam)
  - Followed by non absorbable nasal packing x5-7d

- Postop care – CSF Leak Care
  - ICU x 24 hours neurochecks (hematoma, edema)
  - Ceftriaxone
  - Conservative measures, frequent debridements
  - No strenuous activity x 6 weeks
  - 90% successful primary repair, 96% in second attempts
Complications of Pituitary Excision


- Carotid artery injury
  - 1.1%
- CNS injury
  - 1.3%
- Loss of vision
  - 1.8%
- CSF Fistula
  - 3.9%
- Meningitis
  - 1.5%
- Mortality
  - 0.9%

**TABLE 1. Complications of Transphenoidal Hypophysectomy**

- General:
  - Diabetes insipidus
  - CSF leak
  - Meningitis
  - Intracranial abscess
  - Pneumocephalus
  - Ophthalmic deficits
- Local:
  - Epistaxis/hemorrhage
  - Septal perforation
  - Synechiae
  - Mucocoele
  - Sinusitis
  - Paresthesias
  - Speech abnormalities
A clinical bony dehiscence of the cavernous portion of the carotid canal is present in the following percentage of patients:

- A. 2%
- B. 5%
- C. 10%
- D. 22%
- E. 35%
D. A clinical dehiscence is present in approximately 22% of patients.

left sphenoid sinus; 1 = CN II, 2 = ICA, 3 = sphenoid face
You are performing a transnasal transsphenoidal approach for a large pituitary macroadenoma. As you carefully remove the anterior face of the sphenoid with a rongeur you encounter brisk bleeding at the inferior limit of your dissection.

What vessel have you encountered?

- Greater palatine artery
- Posterior septal artery
- Greater sphenoidal artery
- Cavernous portion of the internal carotid artery
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Question

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How might this effect your reconstructive options?
Diabetes Insipidus

- Abrupt onset of polyuria/polydipsia usually within 24-48 hours postop
- Craving for ice-cold water
- Hypotonic urine
  - Specific gravity <1.005
  - Urine osmolality <200 mOsm/kg H₂O.
  - Urine output is typically voluminous (4–18 l daily).
- Serum hyperosmolality and hypernatremia
Diabetes Insipidus

Figure 3: Mechanisms that underlie the pathophysiology of the triphasic pattern of postoperative diabetes insipidus

Complications by Approach

  - Retrospective review of 50 pituitary resections performed via different approaches.
    - Sublabial transseptal with microscopic resection – 15pts
    - Transnasal transseptal with endo resection – 21 pts
    - Total endoscopic approach/resection – 14 pts

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<tr>
<td><strong>Sublabial Approach and Microscopic Resection</strong></td>
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<tr>
<td>Intraoperative complications</td>
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<tr>
<td>Postoperative complications</td>
</tr>
<tr>
<td>Subtotal resections</td>
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<tr>
<td>Recurrences</td>
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<tr>
<td>Hospital stays (days)</td>
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<td>Average length of follow-up</td>
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Conclusions

- Endoscopic approaches are well-suited to otolaryngologists
- Surgery is first line for most tumors except prolactinomas
- Know your anatomy, don’t be over confident
- Endoscopic approaches are associated with improved outcomes, fewer complications, and shorter hospital stays.
Questions?
References