Radiologic Evaluation for Endoscopic Endonasal Skull Base Surgery

Kim O. Learned, MD
Assistant Professor
Neuroradiology
University of Pennsylvania
Expanded Endonasal Approach
EEA

- Best surgical corridor to the entire ventral skull base for diversity of pathologies
- EEA technique, principles and surgical modules
- Role of preoperative CT and MR imaging
- Radiologic Key skull base Anatomy in relation to surgical access and candidacy
- Post-op Imaging Evaluation
EEA Surgical Principles

- Optimal lesion exposure & safe resection
  - Direct surgical route to Ventrally located lesion
  - No crossing critical neurovascular structures
EEA Surgical Modules

- Median region between paraclival ICAs
- Paramedian region lateral to the ICAs
- The location of the lesion dictates the surgical module with step-wise exposure through the nose

EEA Steps

• Binostril access: Endoscopic sinus surgery
• Surgical corridor to skull base by EEA modules
• Endoscopic skull base reconstruction
• Drill bone, grab and cut tissue, dissect

• Hemostasis: pressure application with pledgets, hemostats, bipolar cautery. Cannot suture
Endoscopic Skull Base Reconstruction

• Reconstructive option
  – Free grafts (fascia lata, Duragen, Biodesign, Integra, free mucosa)
  – Vascularized Nasoseptal flaps: harvested after binosotrill access and before surgical resection
Preop Evaluation for EEA candidates

• Midline from behind frontal sinus to clivus
• Flanked by the orbits and ICAs
• No extension posterolateral to ICA or lateral to foramen ovale
## Radiographic Findings That Indicate Contraindications to EEAs

- Brain invasion
- Orbital invasion
- Lateral skull base lesion
- Lesion in superolateral cavernous sinus
- Craniopharyngioma that is isolated to the third ventricle
- Lesion with major component extending over the orbital roof, optic canal and lateral to foramen ovale
- Lesion arising from or extensively involving the frontal sinus
- Lesion displacing the neurovascular structures ventrally
- Inability to reconstruct the skull base defect
Pre-op CT Evaluation

• All cases
  – Bony Dehiscence
  – **Integrity of Nasal Septum & Sphenopalatine Artery** for nasoseptal flap

• Anatomical variants pertinent to surgical approach
  • Heights of skull base (Keros 1-3)
  • Onodi cells, sphenoid sinus pneumatization and septum relationship with ICA, optic canal
  – Bone thickening that requires drilling to reach pathology
Pre-op MR Evaluation

• Its relationship with critical neurovascular structures

• Potential high surgical risk → tumor residua
  – Over orbital roof and optic nerve
  – Behind ICA, encasement of vessels
  – In superolateral cavernous sinus
  – Lateral to foramen ovale
  – Involve pituitary stalk-hypothalamus
Pre-op MR Evaluation

- Lesion location dictates surgical modules
Transcribriform

• **Pathologies:** Esthesioneuroblastoma, Olfactory meningioma, Sinonasal tumor

• **Anatomy:**
  – Back wall of frontal sinus to planum, Lamina papyracea, ACAs

• **Corridor:** ethmoidectomy & frontal sinusotomy DRAF III
Transcribriform Esthesioneuroblastoma

- No frontal sinus involvement
- No brain invasion
- No periorbita invasion
- Midline, not over orbital roof
- Inferior Nasal septum intact
EEA Candidate?

- Over the orbits
- Subpial invasion
Transplanum

- **Pathologies:** Meningioma, access to anterior suprasellar cistern, optic chiasm & 3rd ventricle, pre-infundibular craniopharyngioma

- **Anatomy:**
  - Optic canals, optic chiasm & ICAs
  - Anterior Cir of Willis, Pituitary stalk

- **Corridor:** ethmoidectomy, sphenoidectomy
Transplanum Meningioma

- No lateral extension over or into orbital apex & optic canal
- No extension behind Cir of Willis, chiasm or pituitary stalk
Transplanum
Adenocarcinoma metastasis

- Midline Suprasellar cistern in the Subchiasmatic & Preinfundibular space
Transellar

- **Pathologies:** Pituitary, Access to Suprasellar cistern, Craniopharyngioma
- **Anatomy:**
  - Tuberculum sellae, Sellar floor
  - Optic chiasm
  - ICAs, Cavernous sinus
- **Corridor:** TSA
Cavernous Sinus

- Zones in relation to the cavernous ICA and the CNs
- **Superolateral CS** contains CNs III, IV, VI → “no man’s land” for surgeon because of the high risk of ophthalmoplegia.
Recurrent adrenocorticotropic hormone pituitary adenoma

- Surgical resection of the medial inferior cavernous sinus tumor component
- **Surgical difficulty: Lateral and Superior CS**
Craniopharyngioma

- EEA Sellar-Suprasellar
  - Surgical module depends on relationship of the tumor with pituitary stalk
  - Pre-, Trans- or Retro-infundibular

- Isolated to 3rd ventricle ➔ inaccessible via EEA

Transplanum-Transellar Craniopharyngioma

- Trans-infundibular craniopharyngioma
- Exposure of subchiasmatic space and mobilization of sellar content
Craniopharyngioma

• Extensive tumor in sella, suprasellar cistern, third ventricle, interpeduncular cistern
Combined EEA modules

- Trans-splanum and sella: Pre- and Trans-infundibular tumor exposure $\rightarrow$ anterior 3\textsuperscript{rd} ventricle
- Upper Clivectomy: retroinfundibular tumor exposure $\rightarrow$ interpeduncular cistern and posterior third ventricle
**Transclivus**

- **Pathologies:** clival chondrosarcoma, chordoma, meningioma, access to pre-brainstem cistern, brainstem, posterior 3rd ventricle

- **Anatomy:**
  - Eustachian tube $\rightarrow$ parapharyngeal ICA
  - Vidian canals $\rightarrow$ paraclival ICA
  - CN III along posterior clinoid
  - CN VI in Dorello canal

- **Corridor:**
  - Sphenoidectomy
  - Nasopharyngectomy
  - Clivectomy
Transclival Chordoma

- Clivectomy and tumor dissection maintained in midline to avoid ICA and CN III, VI injury
Post-op MR Evaluation

• Tumor Resection
  – Potential high risk or increase of surgical difficulty
    → intentional tumor residua

• Endoscopic skull base reconstruction:
  – Expected normal findings
  – Post-op CSF leak
Reconstruction Tissue Options

- **Non-vascularized grafts**
  - Small defect
    - Dura Substitute
      - Collagen matrix, Fascia (Lata, Temporalis)
    - Free Mucosal Graft, Dermis

- **Vascularized flaps**
  - Larger defect & Intradural resection
    - Nasoseptal flap
Nasoseptal Flap (NSF)

- Mucoperiosteal-mucoperichondrial
- Elevated off one or both sides of nasal septum
- Vascular pedicle (*) from sphenopalatine artery
- Rotated up to cover the cranial defect

Hadad. Laryngoscope 2006
Endoscopic Skull Base Reconstruction (ESBR) using NSF

- High CSF leak rate
- Multilayer ESBR
  1. Intradural fat
  2. Inlay/Onlay Dura substitute
  3. Free mucosal graft
  5. Glue, support

Post-op MR Imaging Evaluation

Skull Base

- Extent of tumor resection
- Enhancement < 48 hours postop
  - Grafts –
  - Neoplasm +
  - Vascularized Flaps +
Post-op MR Imaging
ESBR-Nasoseptal Flap

Kang. AJNR 2009
Nasoseptal Flap

- T1 and T2 ~ Brain
- Vascular pedicle to SPF
- Enhancing C-shaped flap
Pontine Cavernoma

- Bilateral NSFs: 1 large, 1 small
- T1 and T2 signal similar to brain
- Enhancing Flaps & Vascular Pedicles toward SPF
- 2-10 mm thick

Learned. EJR 2013
Small cell Neuroendocrine Carcinoma

Enhancing Vascularized Nasoseptal flap should not be mistaken for Neoplasm

Learned. AJNR 2014
Post-op MR Imaging Evaluation

- Extent of tumor resection
  - Neoplasm vs Nasoseptal Flap

- Skull base Reconstruction
  - Enhancement of NSF → Flap viability
  - CSF leak incidence increases with arachnoid cistern opening, transclival approach.

Adappa. Laryngoscope 2012
Endoscopic Reconstruction Failure

Flap dislodgement from the defect
Non-enhancing Mucosal Gap

Fistulization
Pitfalls: Pseudo-gap

• Limited distal reach of NSF to cover the most anterior and inferior skull base defect
• Free Mucosal Graft
Summary

• Skull base lesions eligible for endoscopic endonasal approach:
  – Midline lesion from behind frontal sinus to clivus
  – Flanked by orbits, ICAs
  – Not lateral to foramen ovale

• Pre-op CT& MR:
  – Lesion location by surgical modules
  – Its relationship with critical neurovascular structures
  – Availability of Nasoseptal flap
Summary

• Post-op MR:
  – Potential high risk or increase of surgical difficulty → intentional tumor residua
  – Enhancing C-shaped Nasoseptal flap of endoscopic skull base reconstruction should not be mistaken for neoplasm.
  – Flap enhancement reflects its viability and allows visibility of multilayer reconstruction’s close abutment to the skull base.
References