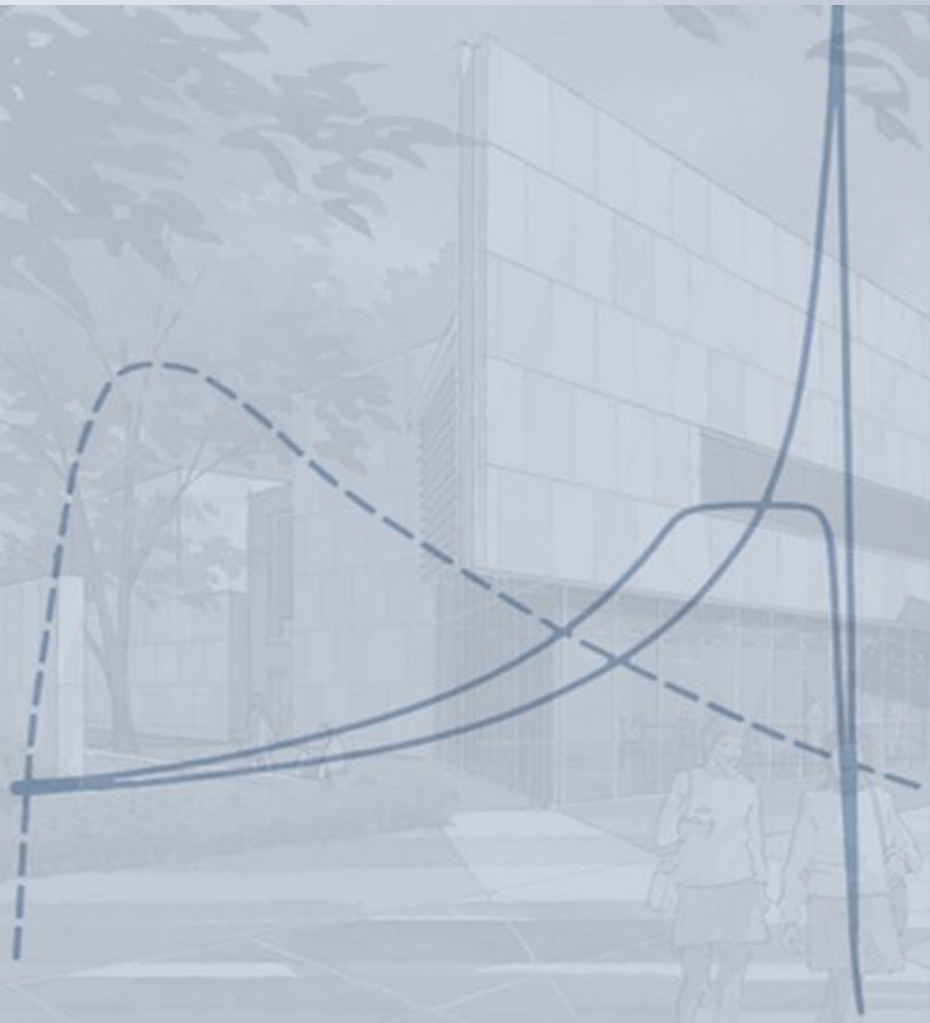
Proton Therapy for tumors of the skull base



Eugen B. Hug, MD

Medical Director,

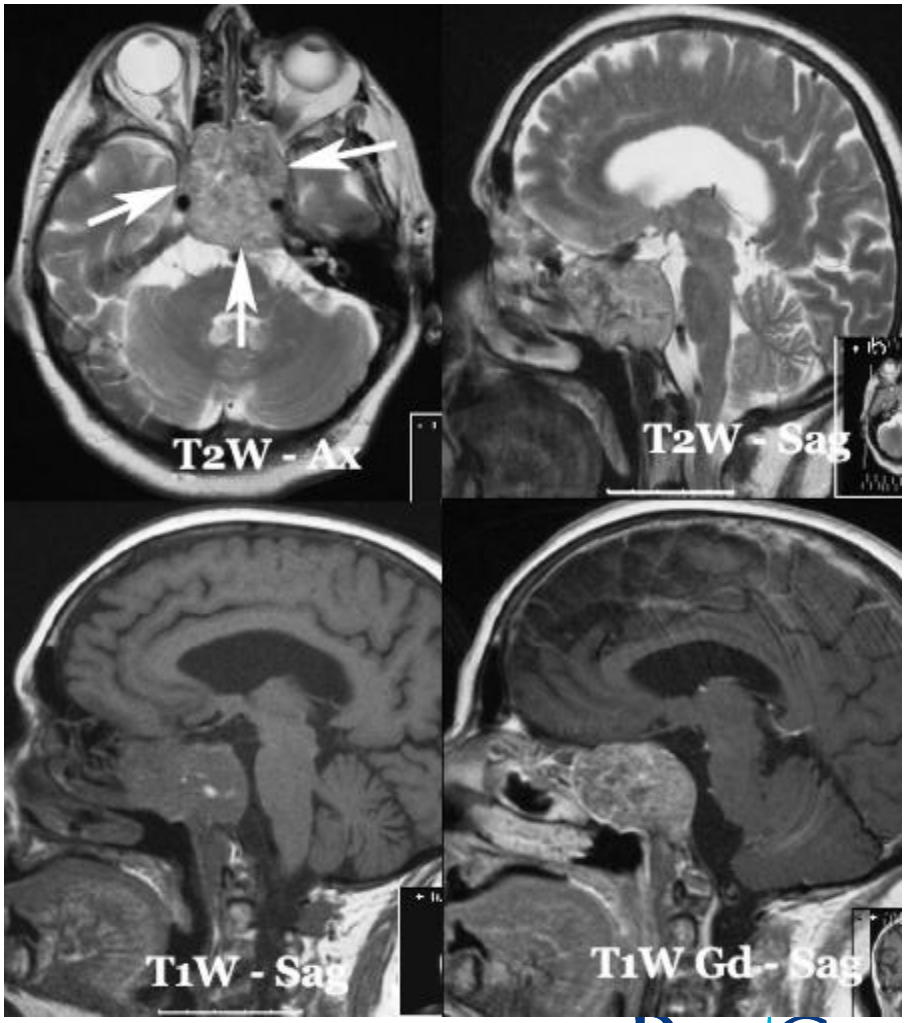
ProCure Proton Therapy Centers, NY

ProCure

Particle Radiation Therapy for Tumors of the Skull Base

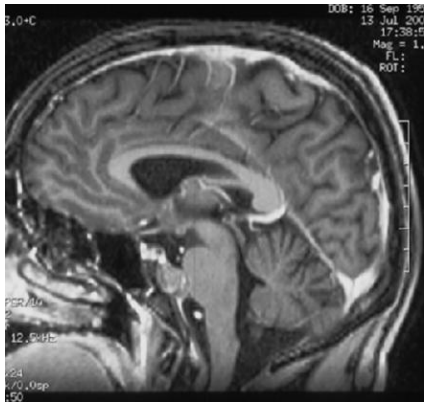
- Primary skull base tumors:
  - Chordoma, Chondrosarcoma
- Primary SB or Secondary infiltration from intracranial tumors:
  - Meningioma
- Secondary infiltration from primary H&N tumors:
  - Nasopharynx CA,
  - Paranasale Sinus CA,
  - Adenoid-cystic CA
  - Rhabdomyosarcomas
  - A.o.

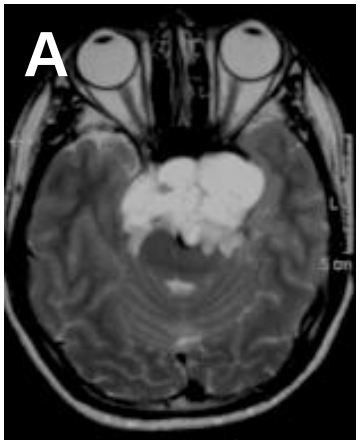
Chordoma

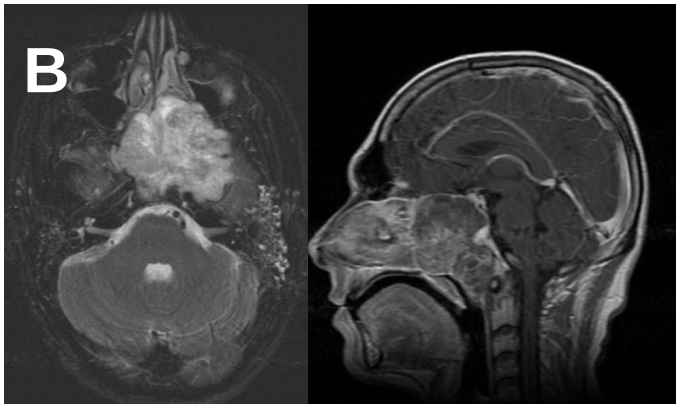


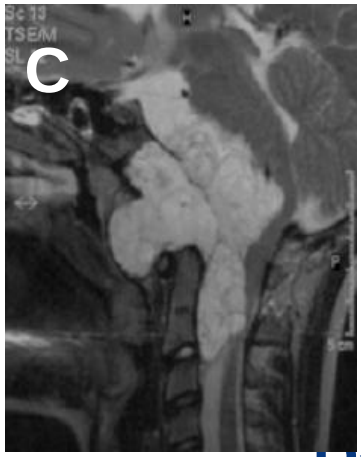
Chordomas of the Skull Base and Occipito-Cervical Junction
Range of tumor sizes treated with proton therapy

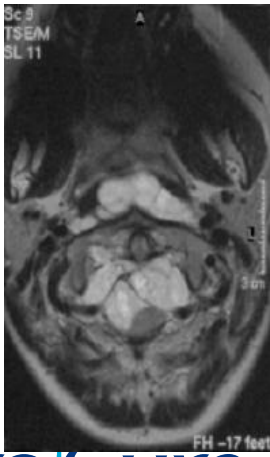
- Rarely: small lesions (< 15-20 cc)
- Frequently: Large lesions (>100 cc)
  - Pre-pontine extension, bilat. middle cranial fossa (A)
  - Extracranial (B)
  - Occipito-cervical junction with large bony destruction, BS and SC compression (C)











Preop. Extensions, large residual GTV's postoperatively

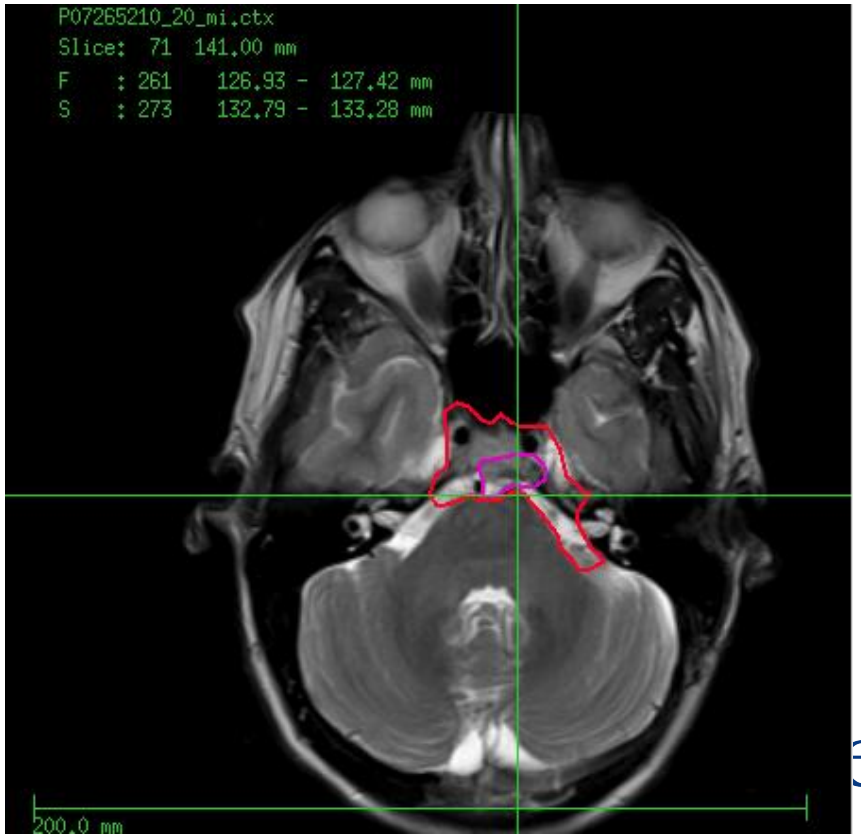
ProCure

Current treatment concepts in fractionated Proton Therapy

Skull Base Chordoma – Proton Target Volume Definitions

GTV = Gross Tumor Volume = residual macroscopic tumor

CTV = Clinical Target Volume = preop. Volume plus anatomic areas at risk for microscopic disease



Skull Base Chordoma and Chondrosarcoma Management issues

- **Target definition**
  - **– GTV (gross tumor volume)= gross residual tumor (and high-risk area in immediate proximity)**
    - **MRI (T1, T1GD, T2, fat sup)**
    - **CT (bone window)**
  - **– CTV (clinical target volume) = postop. tumor bed (taking in account pre-op. extension) plus anatomic compartment, modifying for anatomical boundaries and compartments. Operative access NOT routinely included (risk of operative tumor implants approx. 3-5% - inclusion dependent on anatomic site).**

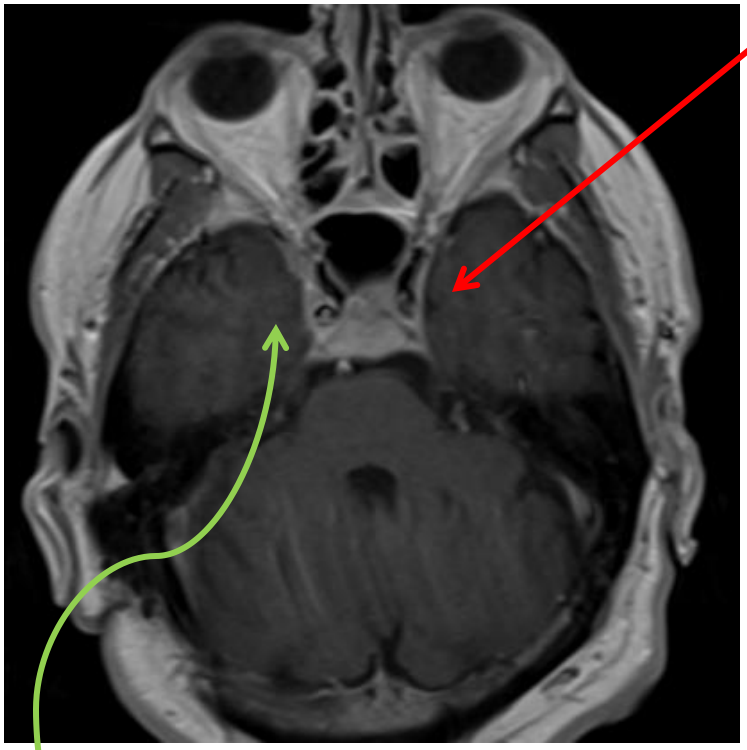
ProCure

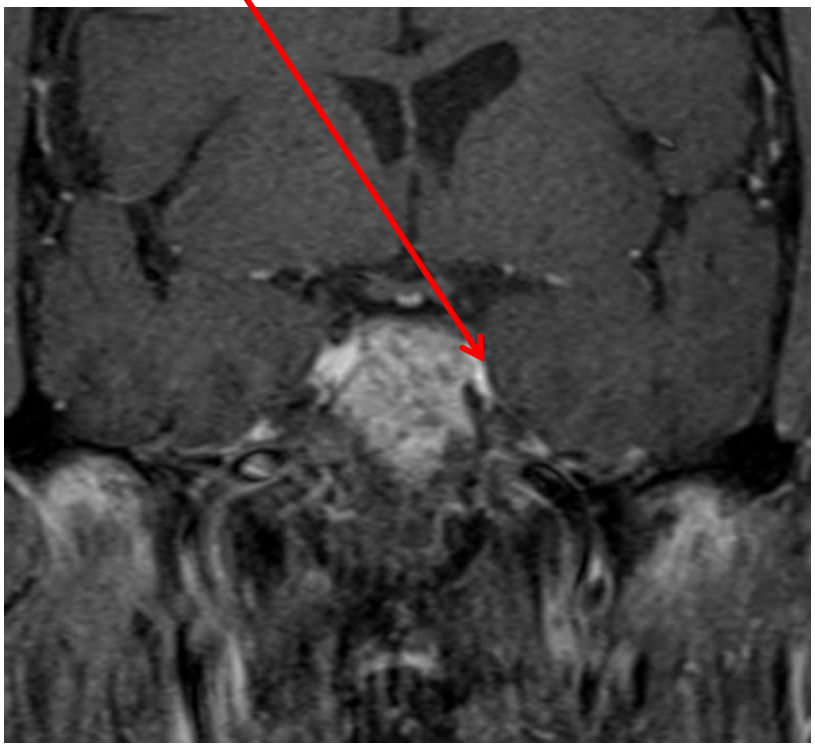
Skull Base Chordomas and Chondrosarcomas - The importance of Oncologic Contouring

6

Skull Base Tumor Contouring: The Cavernous sinus

Normal CS anatomy: CONCAVE on axial and coronal cuts

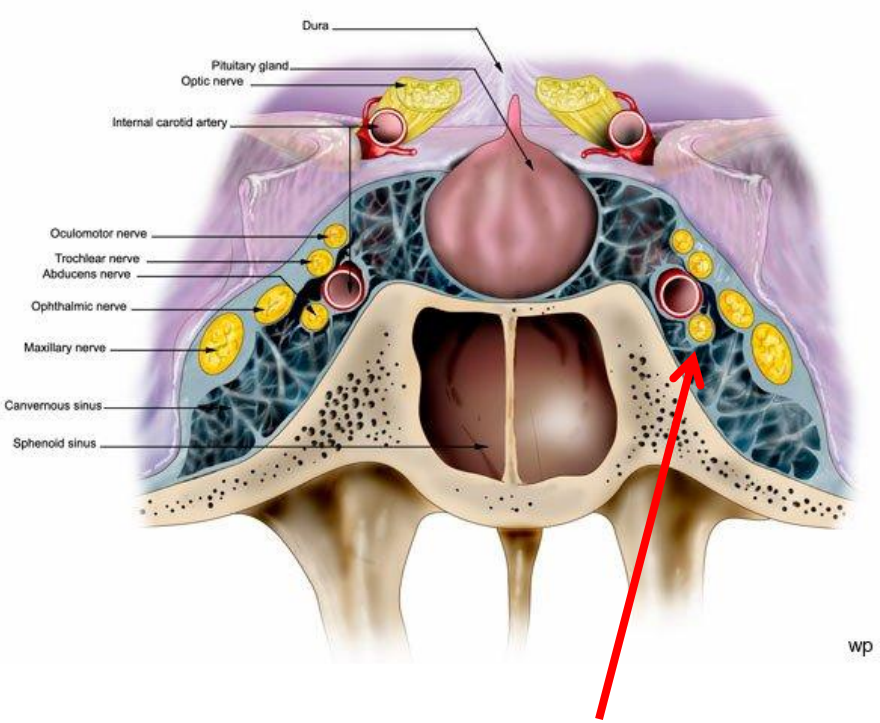


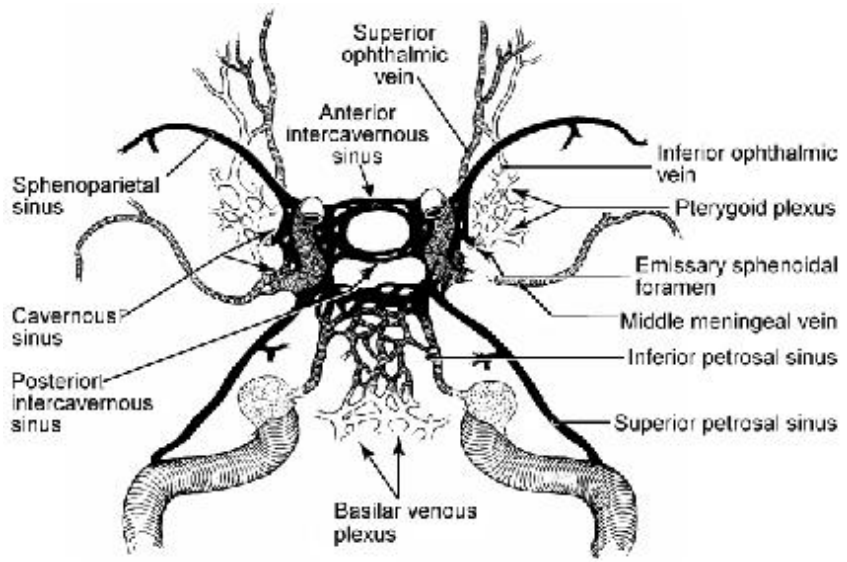


Loss of concavity or difference in signal between CS's indicates involvement !

Skull Base Tumor Contouring: The Cavernous sinus

Cavernous Sinus = "Space" between Dura and Bone





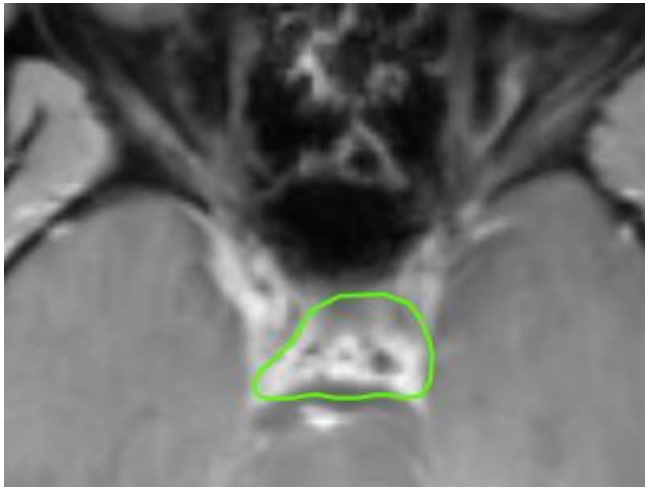
1)6th CN palsy most frequent Sx

2) No internal septations. Once involved, contour ENTIRE CS

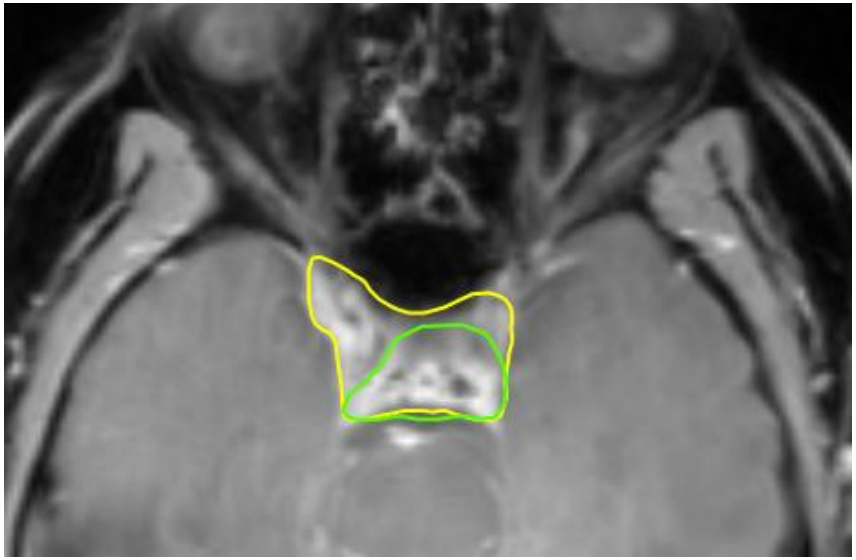
Cavernous sinuses connected via venous complex at posterior wall of clivus

Skull Base Tumor Contouring: The Cavernous Sinus

Example: strict
"Preop. Tumor Contour"



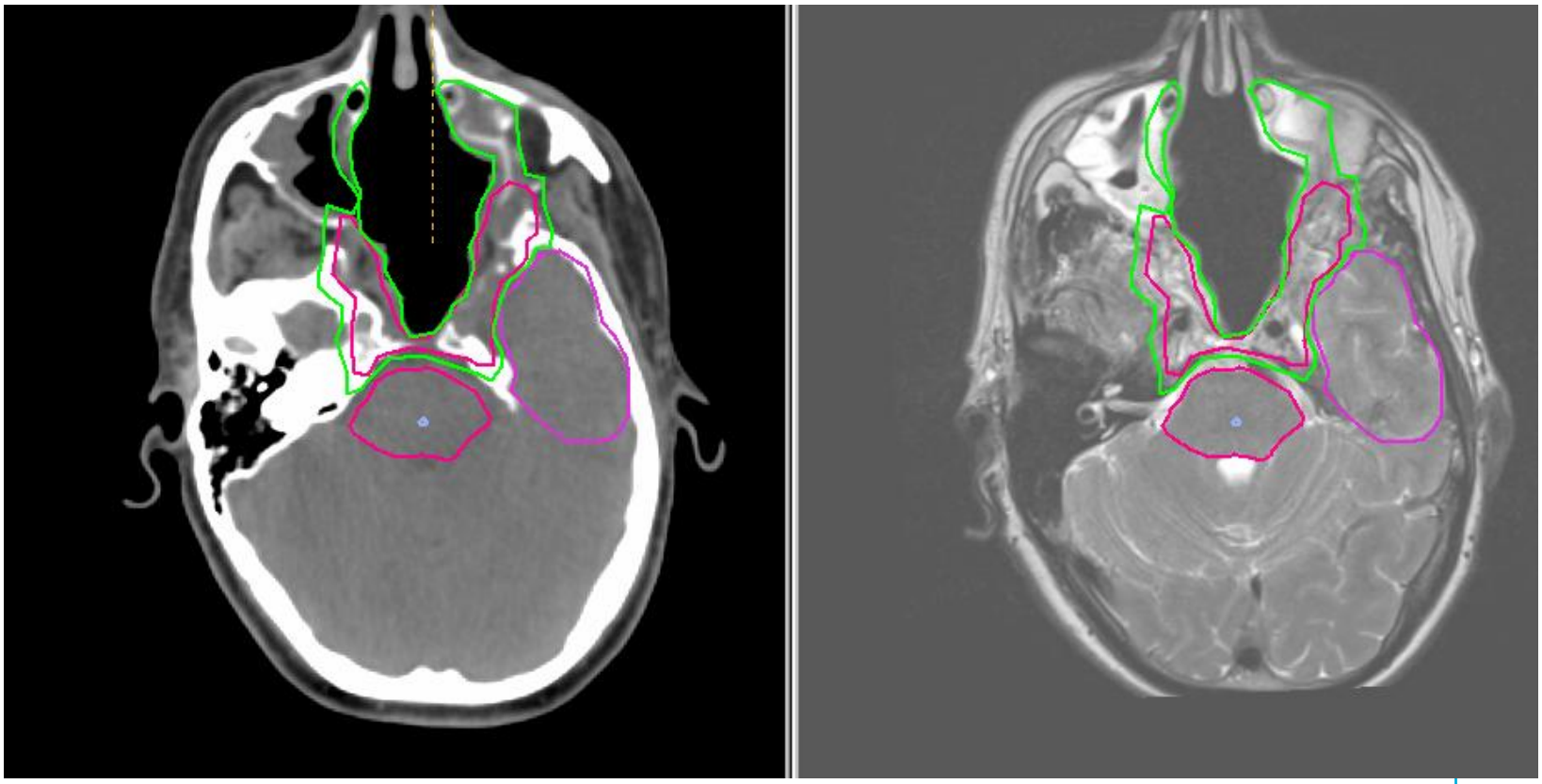
My suggestion:



1) Once CS is involved ENTIRE Sinus needs to be contoured
2) Loss of Concavity or "fullness" suggests involvement
3) Include contralateral sinus at least in CTV

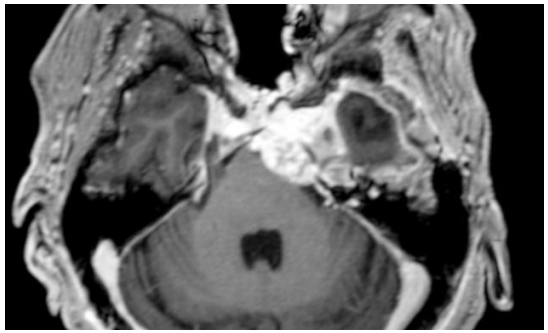
Chordoma Extension into nasal cavity / infratemp. fossa

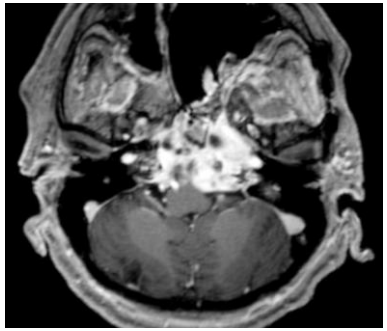
Large chordoma – High dose volume includes gross disease plus high risk / radiographically undetermined. CTV: NOT with automatic expansion, but risk-determined



Target Contouring – Skull Base Chordoma inferior and extracranial extension

Large Chordoma in 68 y.o. female.

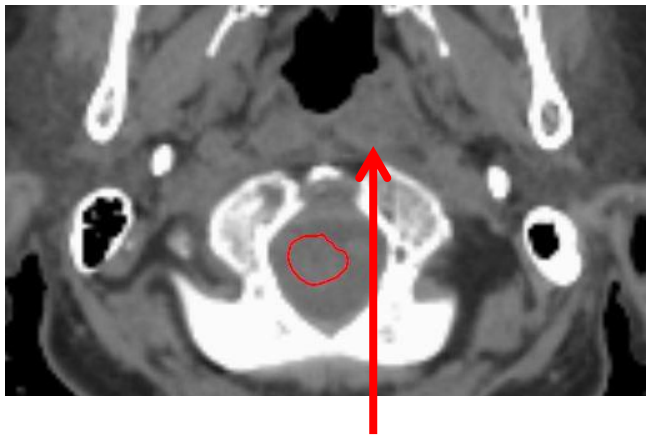




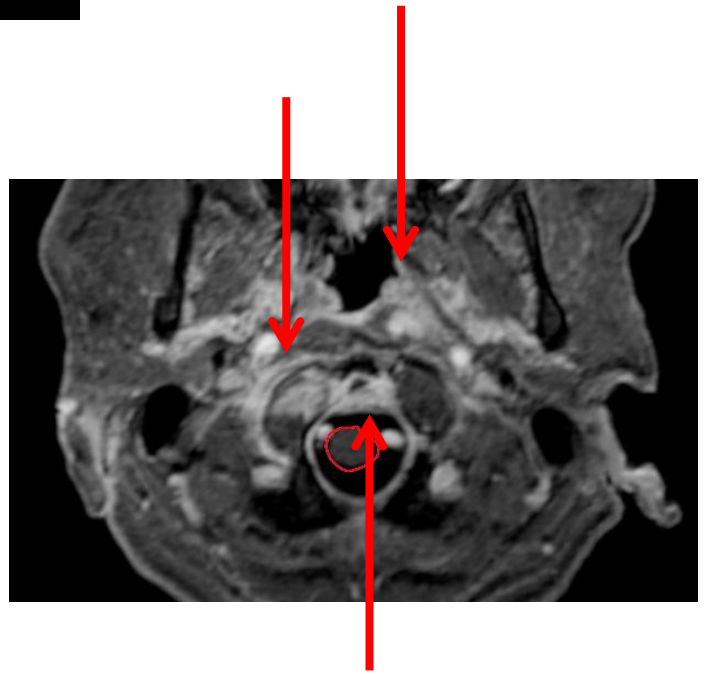
Note: Inferior Extension

- *Frequently non-contiguous extensions*
- *CAVEAT: extracranial extension in posterior pharyngeal tissues*
- *(longus capitis musculature)*

Inferior extension:



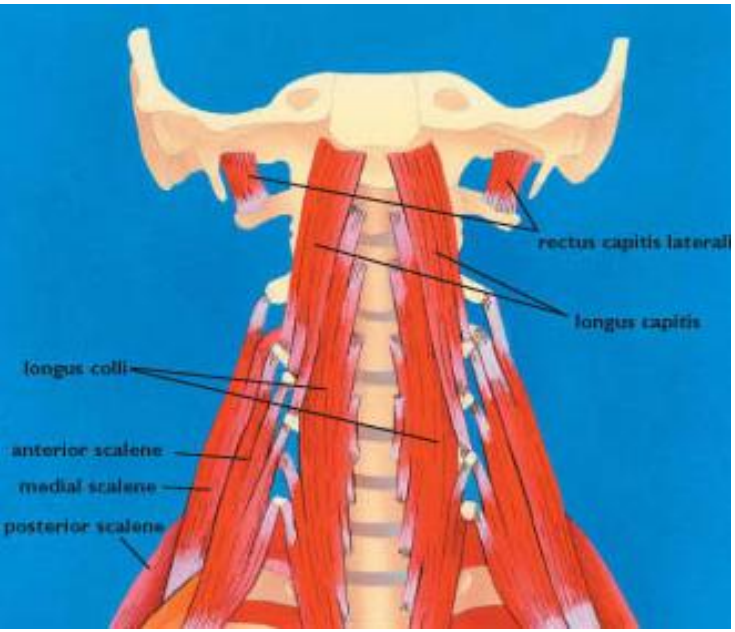
Longus capitis involvement on CT small asymmetry only

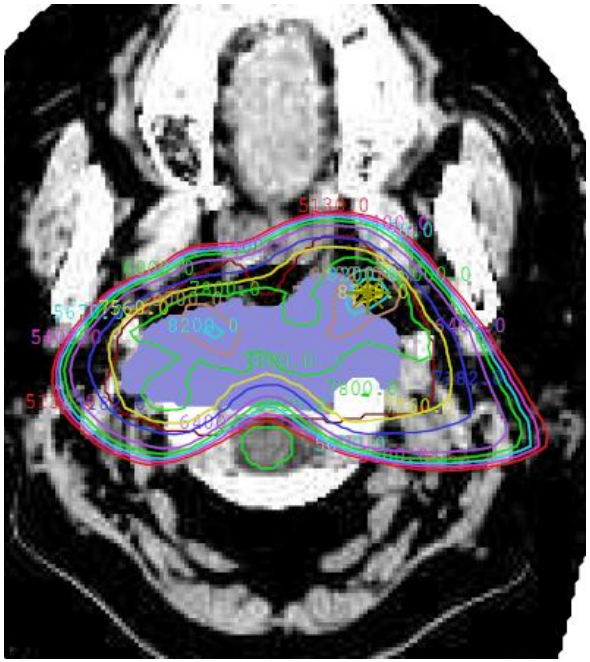


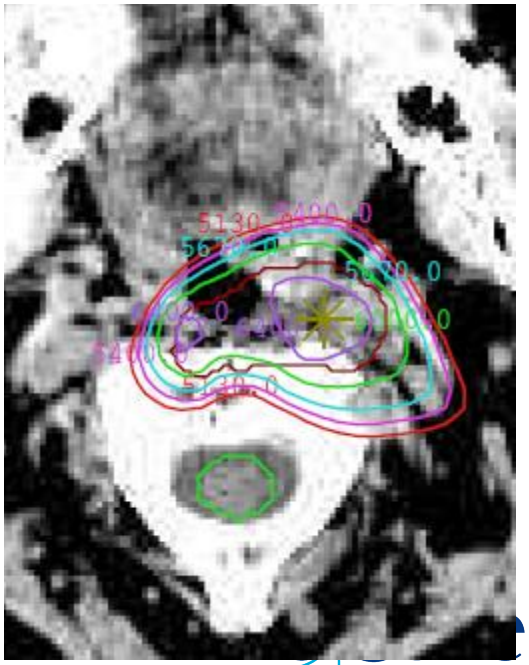
Target Contouring – Skull Base Chordoma inferior and extracranial extension

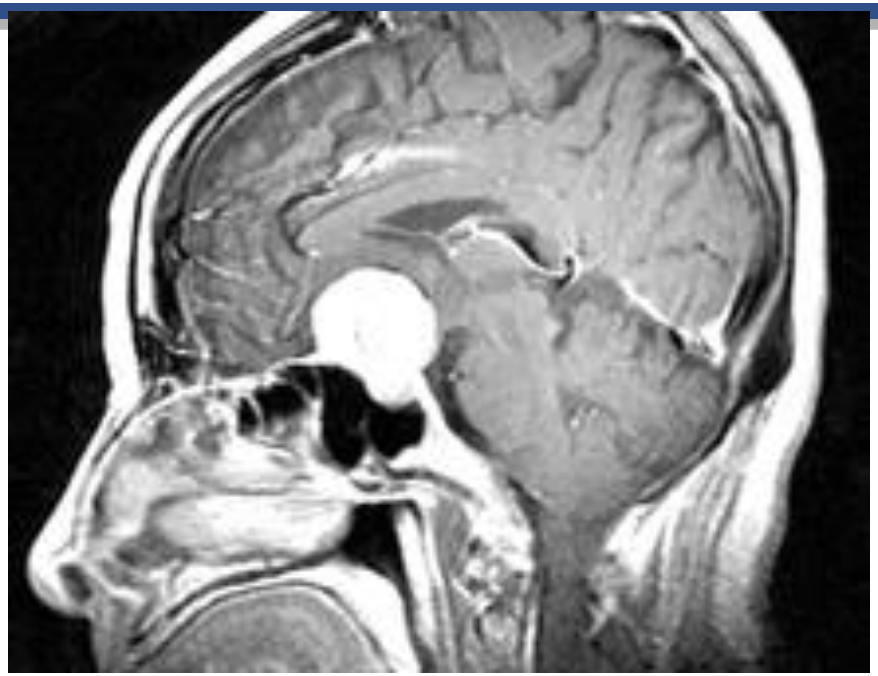
Extracranial Extension: Under-contouring can be significant source of marginal failure

Involvement of posterior pharynx / longus capitis muscle requires generous target coverage – most importantly inferior: Rule: CTV extends 1 vertebral body inferior to GTV as per MRI.





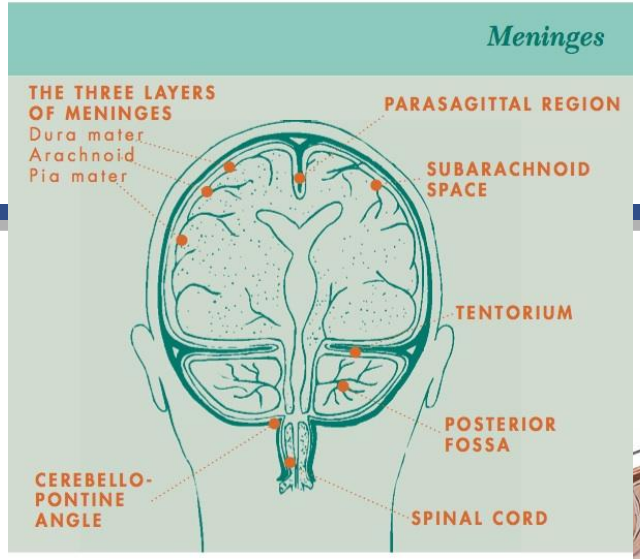




Particle Radiation Therapy for *Meningiomas*

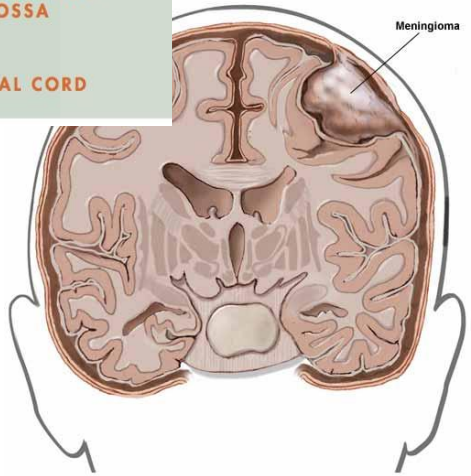
ProCure

Meningiomas:



- Incidence: 2 in100,000 population
- 20% of intracranial tumors
- Arising from arachnoid cap cells (= arachnoid)
- M:F = 1 : 1.4-2.8
- 30-40% multifocal

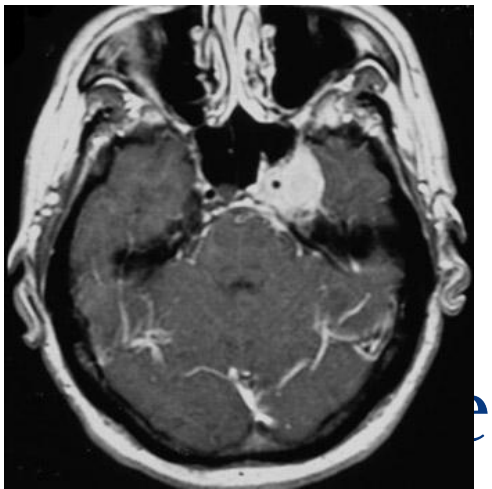
- Recurrence rate after surgery only:
  - Simpson I = 9%
  - Simpson IV minimum 40%



Medscape® www.medscape.com

Grade	Definition of Corresponding Resection
I	macroscopically complete resection w/ excision of dural attachment & abnormal bone
II	macroscopically complete resection w/ coagulation of dural attachment
III	macroscopically complete resection w/o resection or coagulation of its attachment
IV	subtotal resection
V	simple decompression of the tumor

Source: Neurosurg Focus © 2003 American Association of Neurological Surgeons



Meningiomas: WHO Histopathologic Classification

WHO re-classification 2007 *(D. Louis et al, 2011)*

Meningiomas grouped by likelihood of recurrence and grade.

Meningiomas with low risk of recurrence and aggressive growth:	
Meningothelial meningioma	WHO grade I
Fibrous (fibroblastic) meningioma	WHO grade I
Transitional (mixed) meningioma	WHO grade I
Psammomatous meningioma	WHO grade I
Angiomatous meningioma	WHO grade I
Microcystic meningioma	WHO grade I
Secretory meningioma	WHO grade I
Lymphoplasmacyte-rich meningioma	WHO grade I
Metaplastic meningioma	WHO grade I
Meningiomas with greater likelihood of recurrence and/or aggressive behaviour:	
Atypical meningioma	WHO grade II
Clear cell meningioma (intracranial)	WHO grade II
Chordoid meningioma	WHO grade II
Rhabdoid meningioma	WHO grade III
Papillary meningioma	WHO grade III
Anaplastic (malignant) meningioma	WHO grade III
Meningiomas of any subtype or grade with high proliferation index and/or brain invasion	

Note: Brain invasion per se no longer Grade IV

Particle Therapy for MENINGIOMAs:

Benign, complex skull base or multi-centric involvement

Higher-Grade Meningiomas:

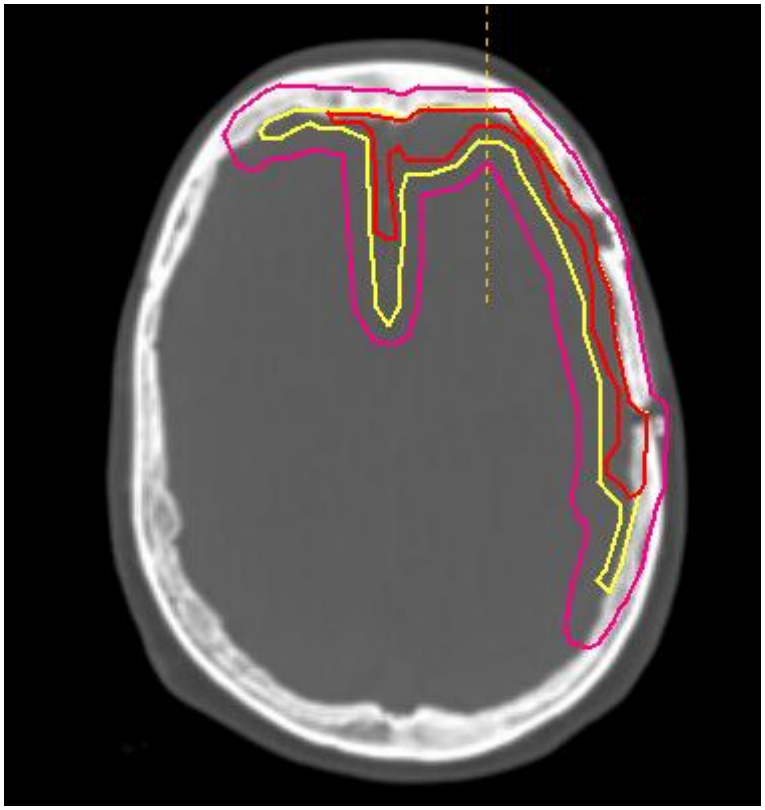
- **atypical**
- **anaplastic**
- **(malignant)**

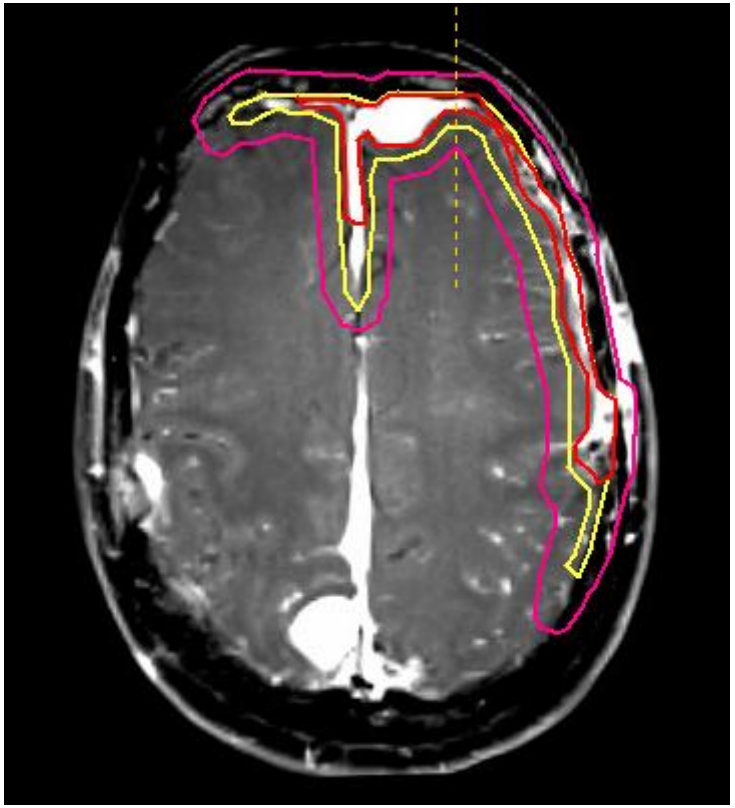
Many small, round meningiomas can be treated well by radiosurgery, stereotactic RT, Cyberknife etc.

ProCure

Atypical meningeoma: GTV, CTV, PTV1.

Note: selective choice to treat only progressive disease in case of multicentrc, extensive disease



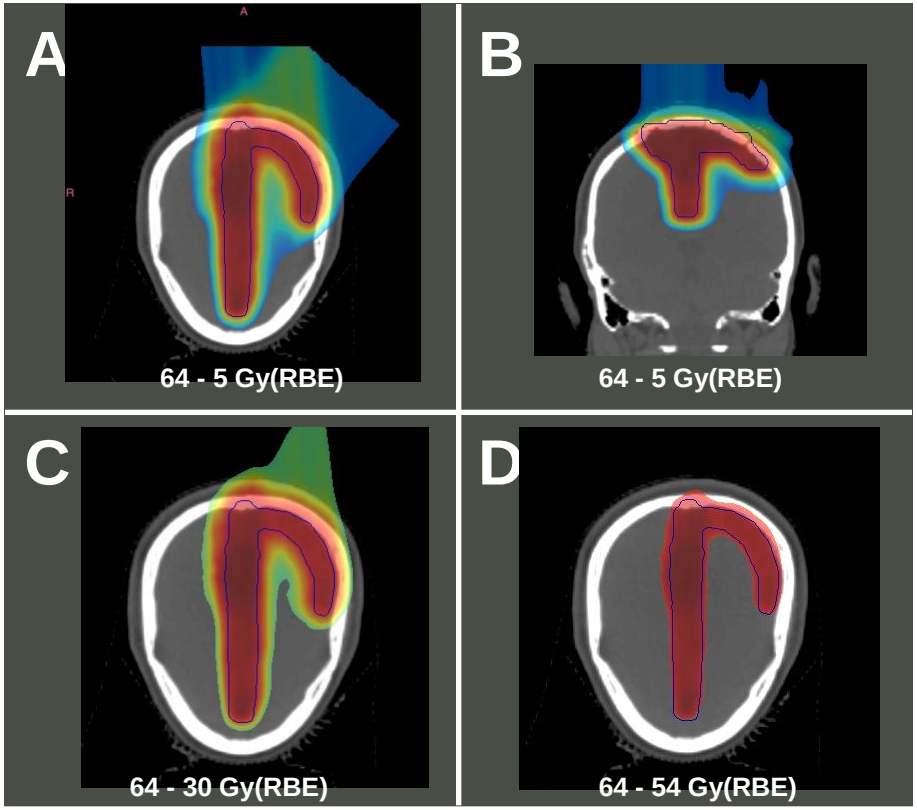


GTV = residual nodular and non-nodular dural enhancement

CTV= 2 cm meningeal margin added to GTV. 2-3 mm intraprenchymal margin added to GTV . Plus respective PTV‘s

ProCure

41 y.o. female patient with atypical meningioma, s/p subtotal resection with residual, complex infiltration of ipsilateral and partial contralateral convexity and falx: GTV dose 64 Gy(RBE) at 2.0 Gy(RBE) / fraction.



Axial (A,C,D) and coronal (B) isodose display. A and B: Display of 64 – 5 Gy(RBE) isodose range. C: Display of the 64 – 30 Gy(RBE) isodose range. D: Display of the 64 – 54 Gy(RBE) isodose range. *Note the limited amount of brain parenchyma receiving 54 Gy(RBE) – the prescription dose most frequently used for benign meningiomas.*

Particle Radiation Therapy for *Adenoid-cystic Carcinoma* of the Skull Base

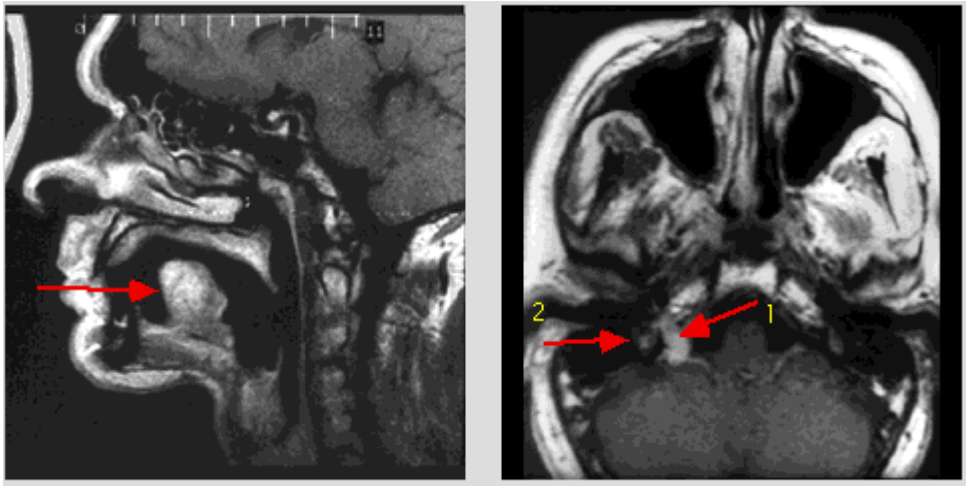
Proton-Radiotherapy for skull base tumors:

Adenoidcystic Carcinoma of the H&N

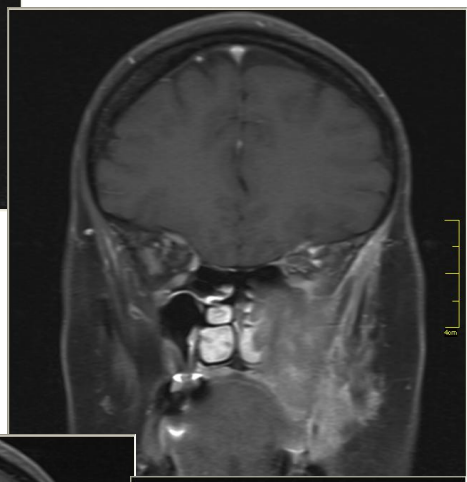
- **Hallmark: Perineural invasion with far proximal recurrence**
- **Late distant metastasis**

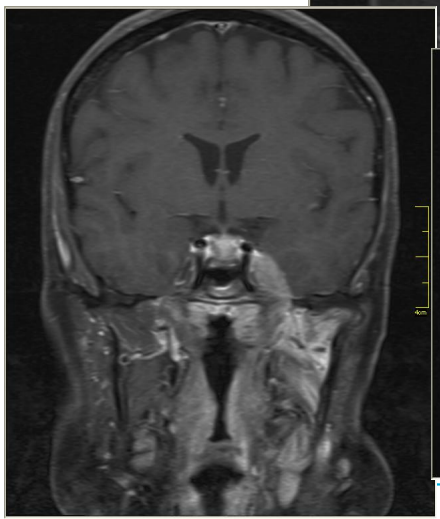
Primary tumor : tongue

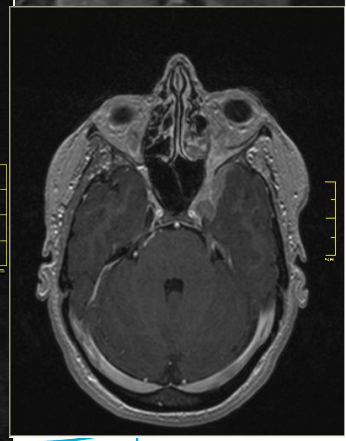
Recurrence at 6 yrs.: skull base



Proton-Radiotherapy for skull base tumors: *Adenoidcystic Carcinoma of the H&N*







Patient: S. S, DoB 15.01.1971

Married, 2 children (2 and 7 years old)

Symptoms:

Left eyelid-weakness (ptosis)
left facial numbness

Diagnosis: (endoscopic biopsy 6/2010)
extensive sino-nasal adenoidcystic Ca. involving left maxilla with infiltration of orbit and skull base
pT4b cN0

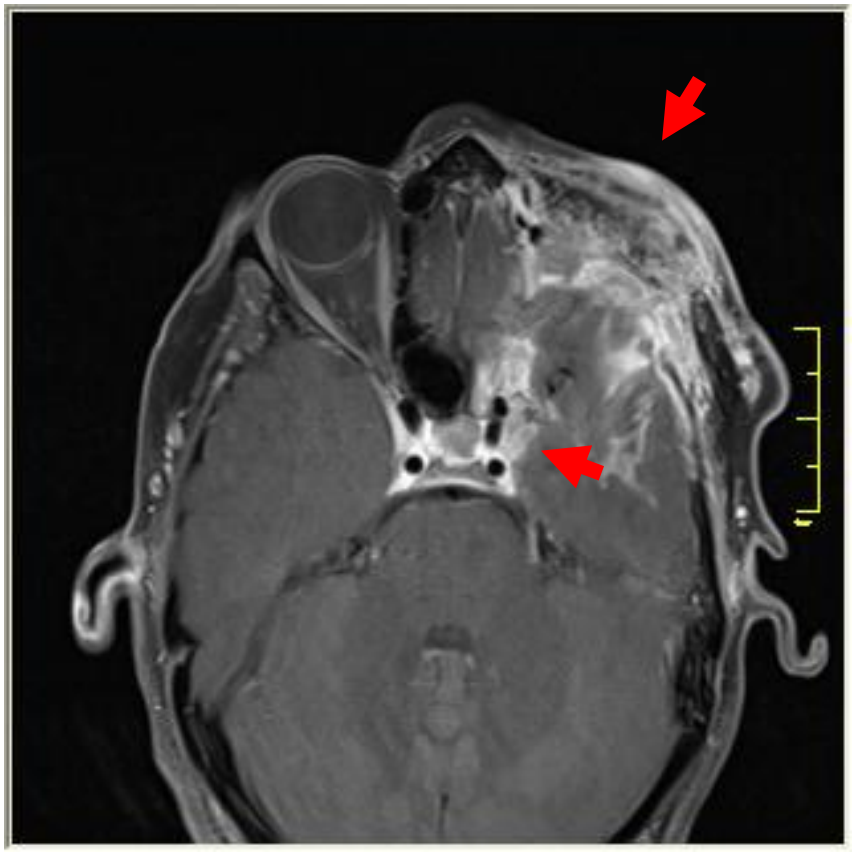
Proton-Radiotherapy for skull base tumors: *Adenoidcystic Carcinoma of the H&N*

Treatment:

Surgery: (8/2010)
transfacial maxillectomy
left orbital exenteration
fronto-spheno-etmoidectomy
revision of the fronto-basal and temporo-basal skull base reconstruction and filling of the defect with rectus abdominis

Postop MRI:

residual tumor left cavernous sinus and beyond



ProCure

Proton-Radiotherapy for skull base tumors: *Adenoidcystic Carcinoma of the H&N*

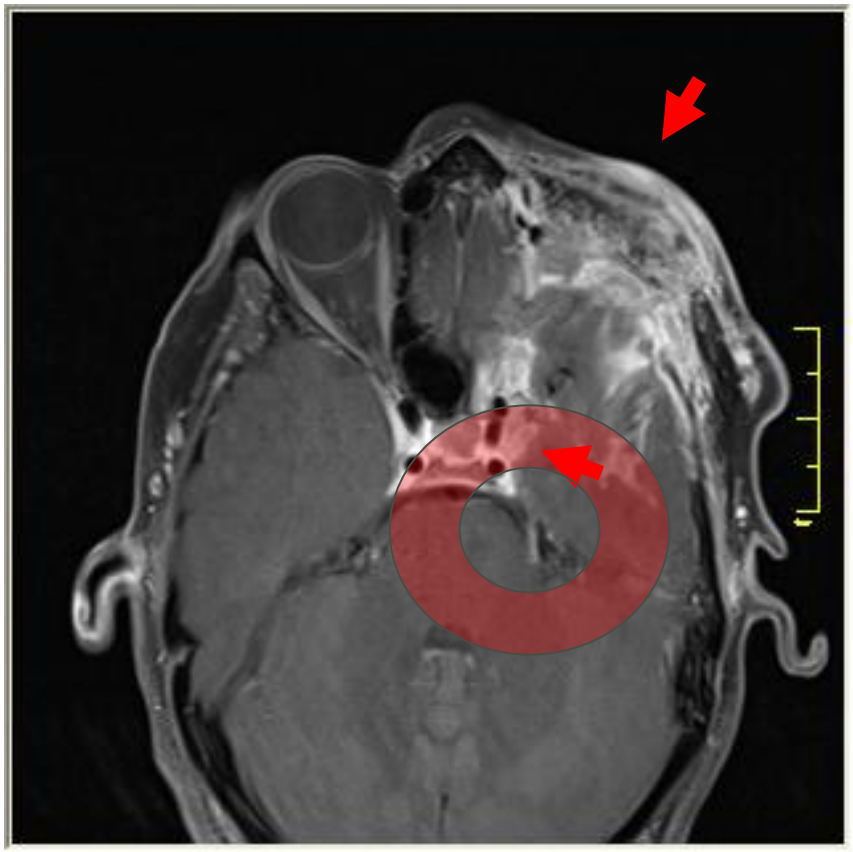
Treatment:

Surgery: (8/2010)

transfacial maxillectomy
left orbital exenteration
fronto-spheno-etmoidectomy
revision of the fronto-basal and temporo-basal skull base reconstruction and filling of the defect with rectus abdominis

Postop MRI:

residual tumor left cavernous sinus and beyond

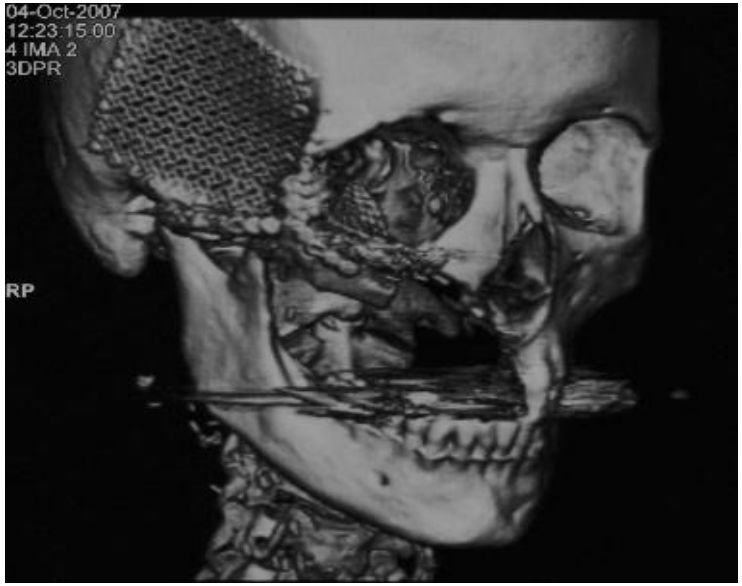


ProCure

Proton-Radiotherapy for skull base tumors: *Adenoidcystic Carcinoma of the H&N*

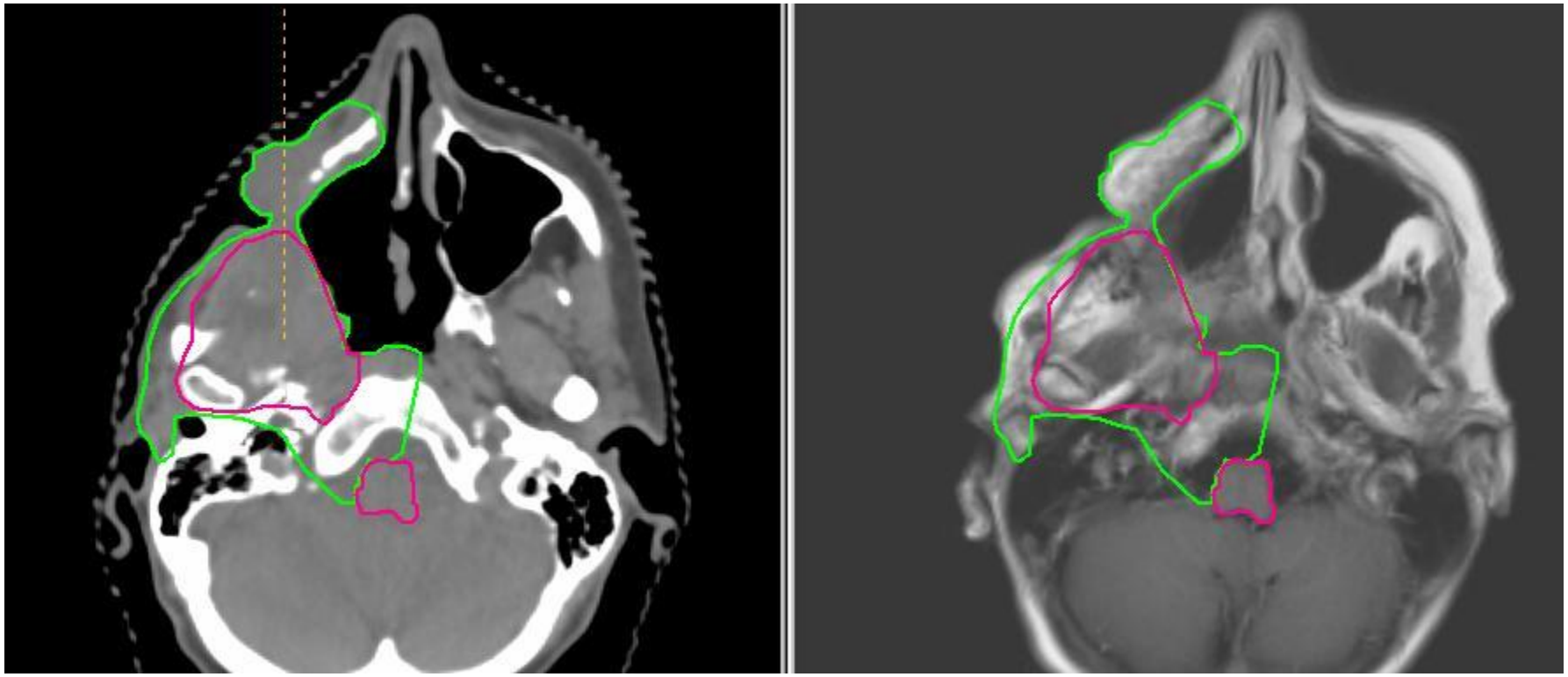
Patient: 64 y.o. F, recurrent ACC,

initial site: right parotid



Proton-Radiotherapy for skull base tumors: *Adenoidcystic Carcinoma of the H&N*

GTV: 72-76 Gy (RBE) CTV: 60 Gy (RBE)



ProCure

…. to be continued