ARROCase: Meningioma

Adjuvant Therapy for High-grade Disease

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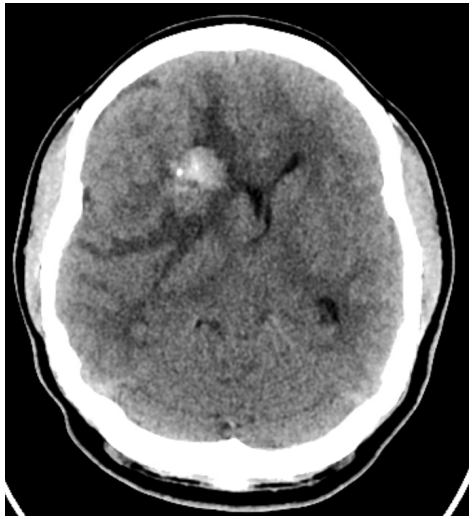
Case Presentation

- 22 y.o. female presented with a one month history of neck pain and headache
- ROS notable for associated blurred vision and pulsatile tinnitus
- PMHx, PSHx, FHx, Soc Hx all unremarkable
- On physical examination she was noted to have right-sided visual field deficit and optic disc edema (neurological exam otherwise unremarkable)
- She was directed to the emergency center for further evaluation

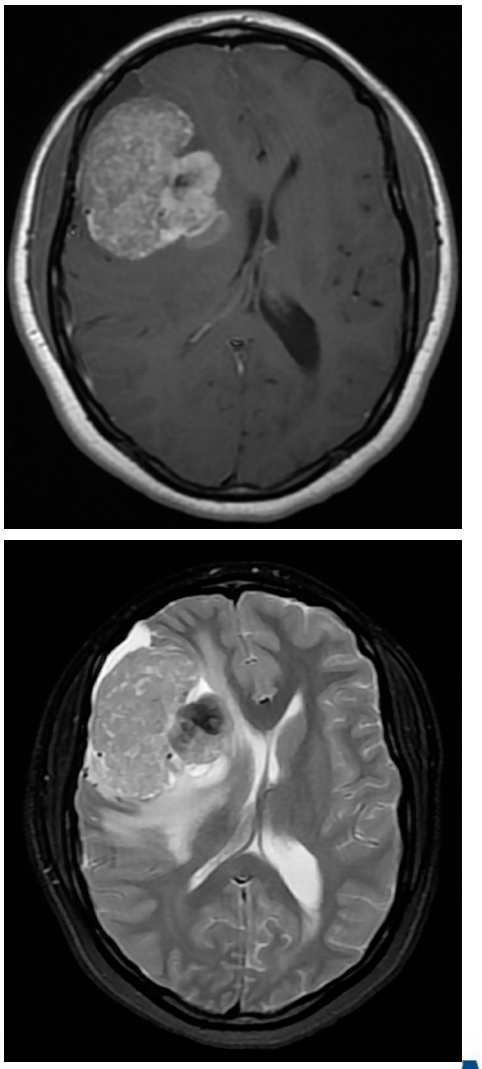
Imaging - CT

- Hemorrhagic partially calcified mass in right frontal lobe with significant mass effect measuring 2.5 x 1.8 x 1.9 cm
- Midline shift of 1.1 cm with associated uncal herniation



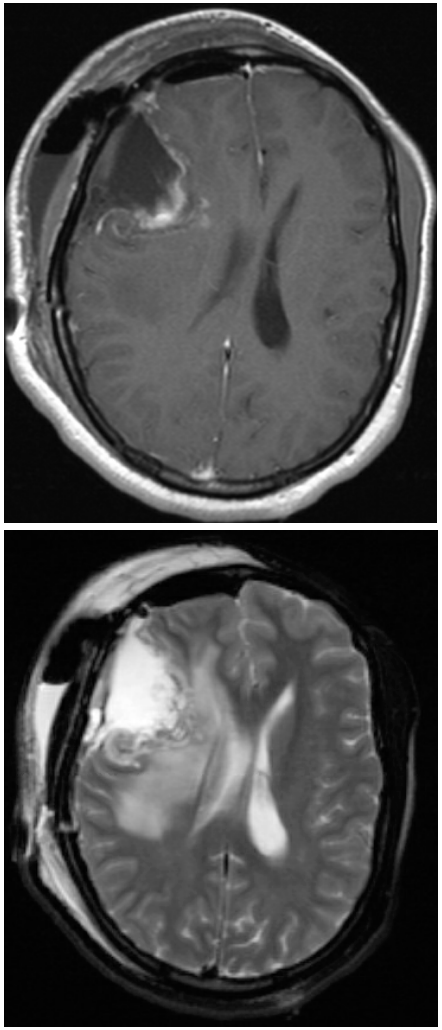
Imaging - MR

- Large, complex heterogeneous intra-axial right frontal lobe mass measuring 6.2 x 5.8 x 6.2 cm
- Mass was primarily hypointense on T2-imaging with diffusion restriction with intense contrast enhancement
- Extensive edema with 8mm midline shift



Initial Management

- Underwent right frontal craniotomy with Stealth Navigation
- Gross total resection achieved
- Surgical pathology revealed WHO Grade 3 meningioma with papillary and focal chordoid features (25 mitoses/10 HPF)



Meningioma

Background

- Meningioma is the most common primary brain tumor in adults (39%)[1]
- Classified as either benign (WHO I – 80%), atypical (WHO II – 18%), or malignant (WHO III – 2%)[2]
- Annual incidence is ~37,000 cases
- Higher incidence in women and AA
- Age has significant impact on prognosis:[1]

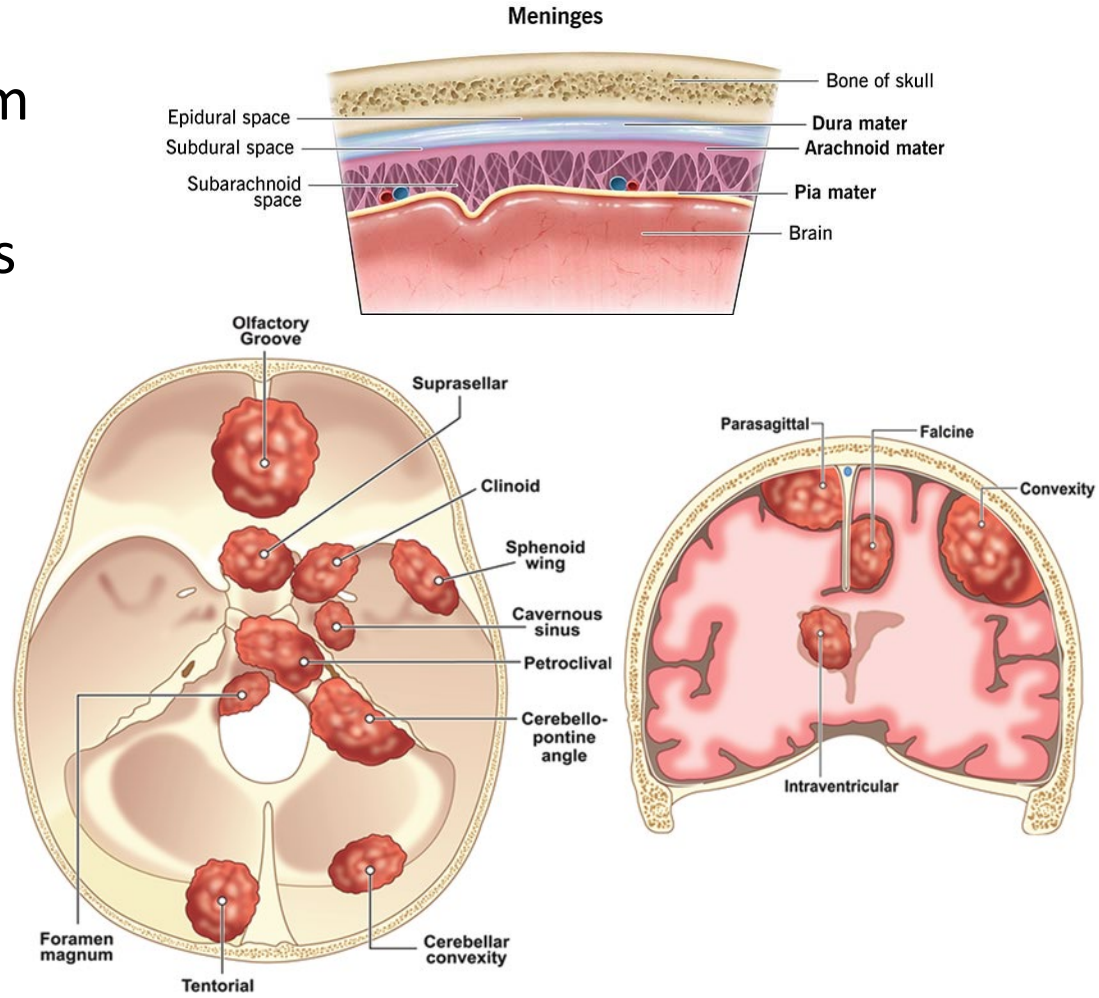
Age (y)	5-yr OS (Benign)	5-yr OS (Malignant)
≤ 14	96%	78%
15-39	97%	83%
≥ 40	87%	66%

Risk Factors

- Increasing age
- Ionizing radiation (latency 20-30 years)[3]
- Genetic mutations (NF2, MEN1)[4]
- Elevated BMI/sedentary lifestyle[5]
- Breast cancer[6]
- Increased estrogen exposure (controversial)[3]

Anatomy

- Meningiomas arise from the arachnoid layer at sites with high densities of arachnoid villi:[7]
  - Convexity (~20%)
  - Parasagittal (~16%)
  - Falx (~11%)
  - Sphenoid wing (~10%)
  - Tentorium (~9%)



8. Cleveland Clinic. “Meninges: What Are They?” Cleveland Clinic, January 11, 2022.

Pathology (WHO 2021)

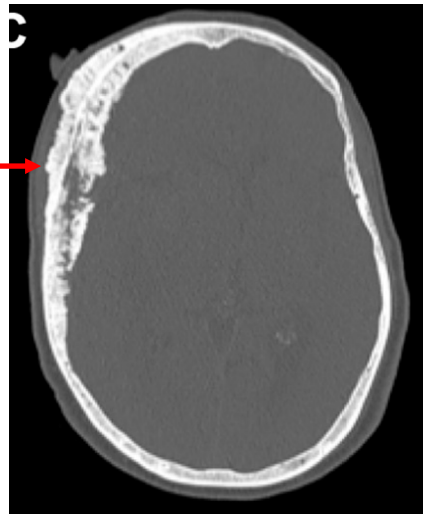
- WHO Grade 1 (Benign)
- WHO Grade 2 (Atypical)
  - Chordoid, Clear Cell
  - 4-19 mitoses/10 HPF
  - Brain invasion
  - ≥ 3 of the following:[9]
    - Increased cellularity
    - Prominent nucleoli
    - Necrosis
    - Sheet-like growth
    - Small cells with high nuclear to cytoplasmic ratio
- WHO Grade 3 (Anaplastic/Malignant)
  - ≥20 mitoses/10 HPF
  - Sarcoma or melanoma-like appearance
  - TERT promoter mutation or homozygous CDKN2A/B deletion[7]
  - Note: Papillary/rhabdoid histology alone no longer sufficient for Grade 3 classification[10]

Clinical Presentation

- Asymptomatic in many cases
- Can often present as seizure (up to 30% of cases)[11]
- Otherwise highly variable depending on tumor location:
  - Visual changes (parasellar, optic nerve sheath, cavernous sinus, occipital)
  - Hearing changes (cerebellopontine angle)
  - Mental status changes (frontal)
  - Extremity weakness (parasagittal, foramen magnum, spinal)
  - Obstructive hydrocephalus (posterior fossa)

Workup

- H&P
- CT-Head
  - Isodense with normal parenchyma
  - Calcification
  - Hyperostosis[12]
- MRI-Brain (gold standard)
  - Extra-axial dural-based mass (dural tail common)
  - Homogeneously enhancing
  - T1 isointense
  - CSF Cleft[13]
  - Increased rates of edema on T2 flair with Grade 2/3 tumors
- Octreotide/Dotatate scan[14]
  - Consider when diagnostic doubt exists
- Biopsy not required for formal diagnosis



Natural History & Prognosis

- Increase in diameter by about 1-2 mm per year
  - Corresponds to volumetric increase of ~15% per year[15]
- Recurrences are predominantly local, and rates vary by grade:[16]
  - Grade 1: ~10%
  - Grade 2: 29-52%
  - Grade 3: 50-94%
- Local progression can cause recurrence or progression of neurological symptoms

Management

- Observation
- Surgery
- Definitive RT
- Factors to consider:[17]
  - Patient characteristics (PS, age, comorbidities)
  - Tumor characteristics (size, grade, growth rate, symptoms, proximity to critical structures)
  - Treatment success likelihood (ability to achieve GTR, SRS coverage, ability for re-treatment)
  - Toxicity associated with treatment approach

Observation Principles

- Preferred for small (≤3 cm) asymptomatic tumors[17] or patients with limited life expectancy
  - Initial follow-up MRI at 3-6 months
  - Annual MRI for 3-5 years
  - MRI every 2-3 years thereafter (so long as patient is still a candidate for intervention)
- Intervention rate for small, asymptomatic tumors is ~25% at 4 years[18]

Surgical Principles

- Preferred for accessible tumors when treatment is indicated[19]
- Complete resection associated with significant improvement in local control and PFS[20,21]
- Often provides immediate improvement in symptoms due to mass effect
- Adjuvant radiation therapy considered based on:
  - Tumor grade
  - Degree of resection
  - Symptoms
  - Potential morbidity of lesion recurrence (e.g., cavernous sinus lesion)

Simpson Grading

- Simpson grading system used to define extent of resection:[22]

Grade	Degree of Resection	Comment	10-Year Recurrence
I	Complete	Resection of dural attachment and any abnormal bone	9%
II	Complete	Coagulation of dural attachment	19%
III	Complete	No resection or coagulation of dural attachment	29%
IV	Subtotal	N/A	44%
V	Simple Decompression	N/A	100%
All	All	N/A	23%

Adjuvant Radiotherapy

- Per NCCN Guidelines:[18]
  - **Grade 1**: Consider only if symptomatic
  - **Grade 2**: Consider after complete resection, indicated for incomplete resection
  - **Grade 3**: Indicated regardless of degree of resection
- Typical doses are 50-54 Gy for Grade 1 and 54-60 Gy for Grade 2-3[23-25]

Definitive Radiotherapy

- IMRT, VMAT, Protons all appropriate depending on given clinical scenario
- Optimal dosing is unknown
- Conventional Fractionation (1.8-2 Gy/Fx)
  - Grade 1: 50-54 Gy
  - Grade 2: 54-60 Gy
  - Grade 3: 59.4-60 Gy
- SRS/FSRT (esp. for suspected Grade 1 tumors)[17]
  - FSRT preferred for larger tumors, high edema risk, Re-RT, or close proximity to optic tract (< 3 mm)
  - SRS dosing 12-16 Gy
  - FSRT dosing 25-50 Gy / 5 Fx
  - Dose typically prescribed to 50% IDL for GK and 80% IDL for LINAC-based

RTOG 0539

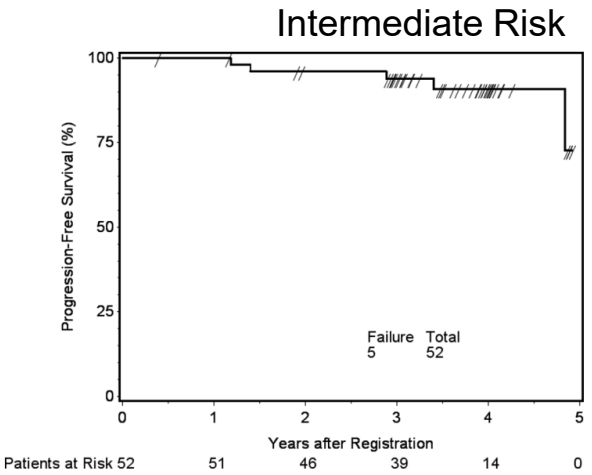
- Phase II study of 244 patients with meningioma stratified into three risk groups:[23-25]

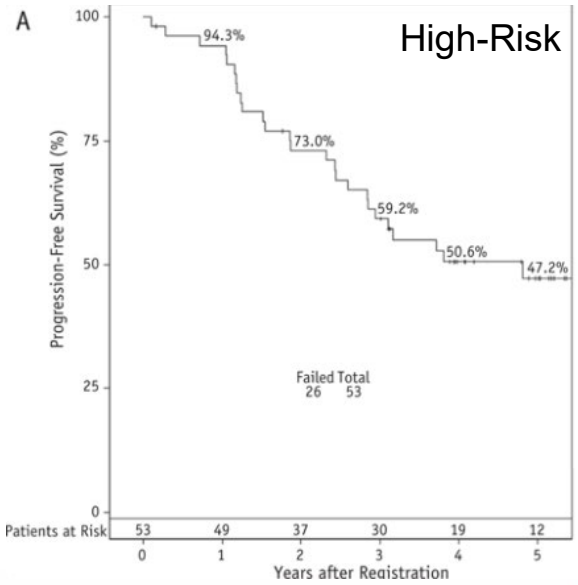
Risk Group	Definition	Management
Low	Grade I (GTR or STR)	Observation
Intermediate	Recurrent Grade I Grade II (GTR)	IMRT to 54 Gy/30 Fx
High	Grade II (STR) Recurrent Grade II Grade III (any resection extent)	IMRT to 54 Gy/30 Fx with SIB to 60 Gy

RTOG 0539

Risk Group	Outcome
Low	5-year PFS 86% 5-year LC 87.5%
Intermediate	3-year PFS 94% 3-year LC 96%
High	3-year PFS 59% 3-year LC 69% 3-year OS 79%

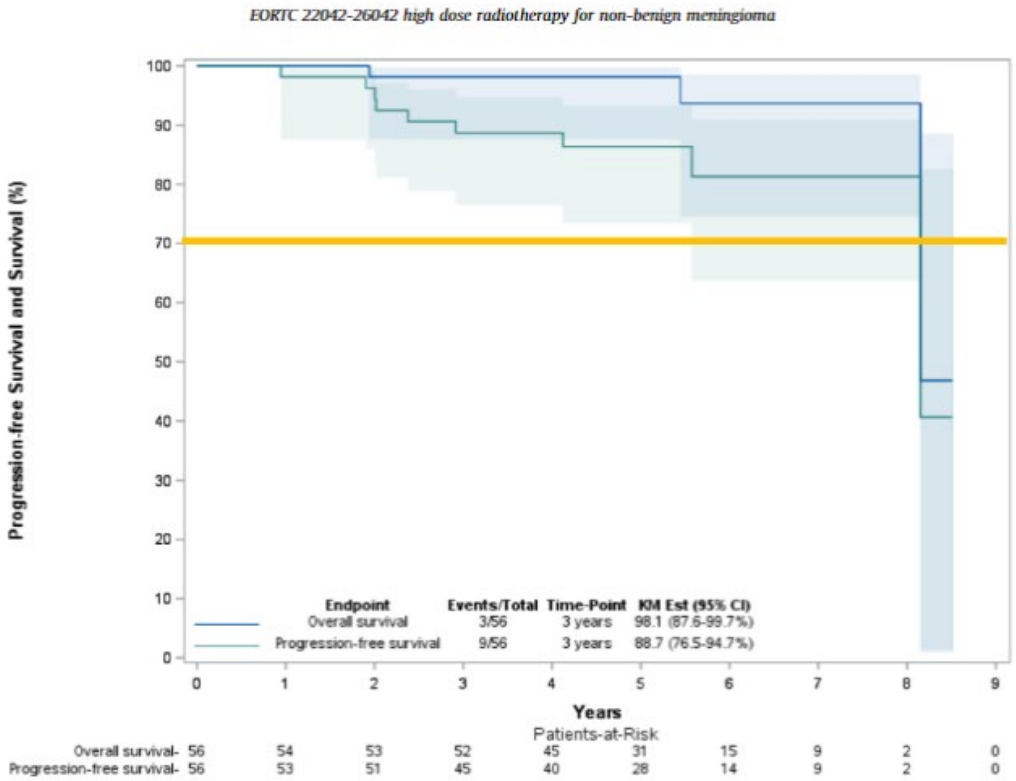
- Increased progression rate with STR vs GTR
- Results justify adjuvant RT for recurrent Grade I and any Grade II/III





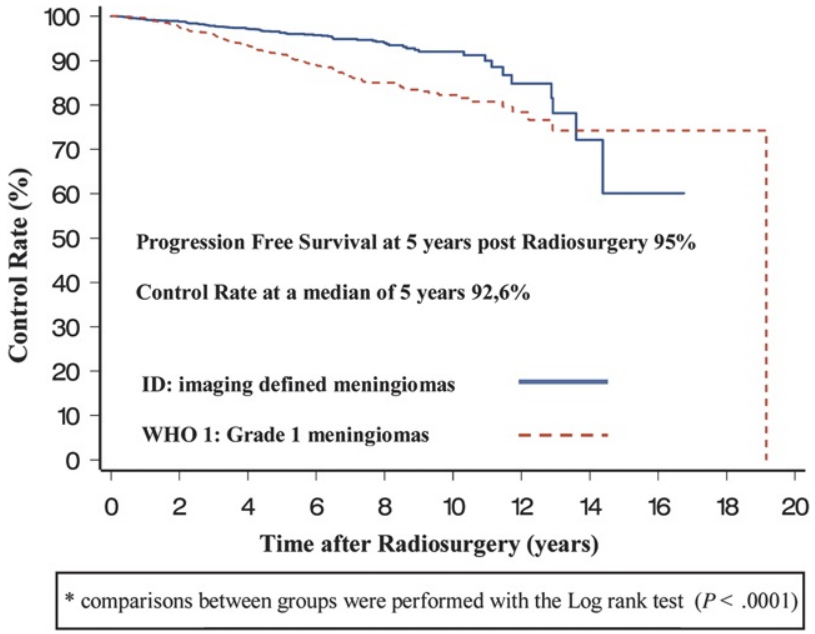
EORTC 22042-26042

- Non-randomized phase II study (N=78) of adjuvant RT following resection of Grade II and III meningiomas[26]
  - Simpson Grade 1-3 patients received 60 Gy
  - Simpson Grade 4-5 patients received 70 Gy
- WHO Grade 2 patients with Simpson Grade 1-3 resection had 3-year PFS of 88.7% (anticipated 70%)
- 3-year PFS of WHO Grade 3 patients was 87.5% (N=9)



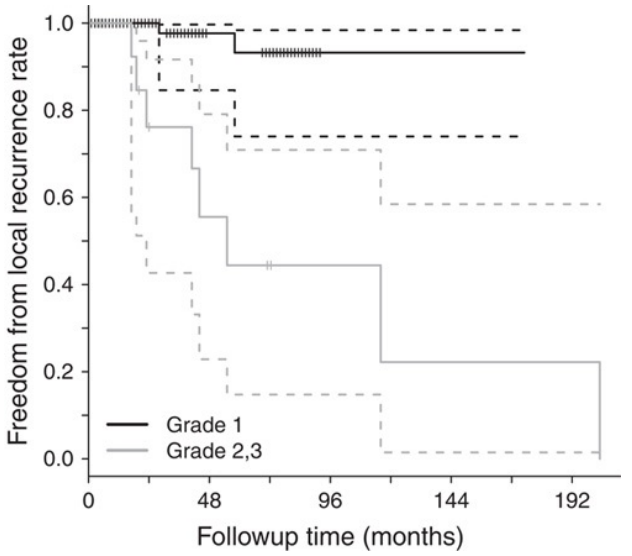
SRS – Grade 1

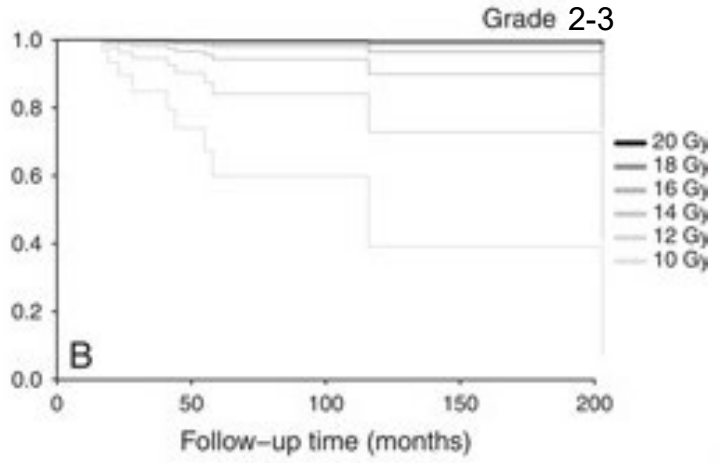
- Santacroce et al. review of 4565 patients with 5300 benign meningiomas treated with SRS[27]
- Median marginal dose was 14 Gy
- Median follow up was 63 months
- Local control was 92.5%, and only 2.2% of tumors required additional treatment



SRS – Grade 2-3

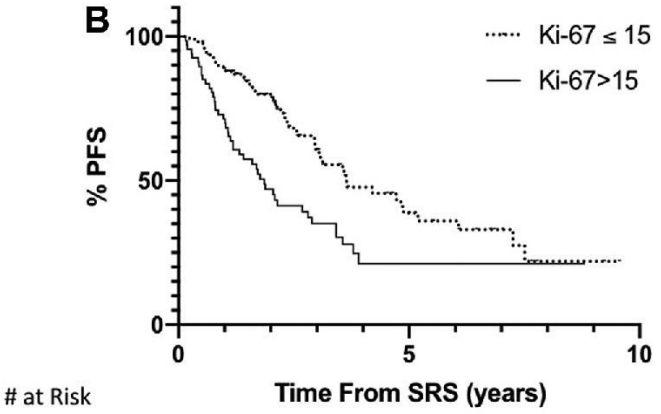
- Sethi et al. retrospective review of 108 tumors treated with SRS[28]
- 11% WHO 2 and 7% WHO 3 (18/20 had surgery prior to SRS)
- 5-year LC was 98% for Grade 1 and 56% for Grade 2-3
- Median dose was 14 Gy for Grade 1 and 16 Gy for Grade 2-3
- Grade 2-3 and lower dose associated with increased local failure



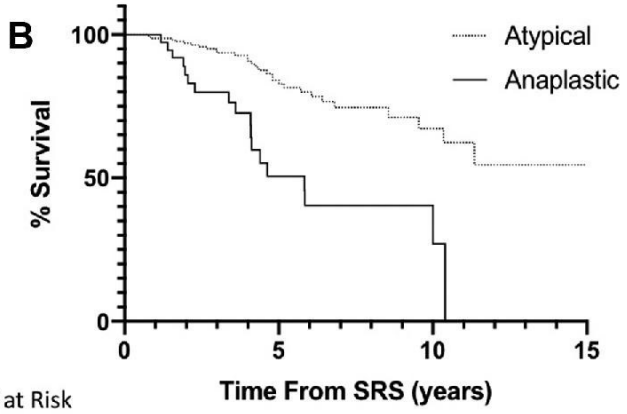


SRS – Grade 2-3

- Shepard et al. retrospective review of SRS for atypical (N=233) and malignant (N=38) meningiomas[29]
- 97% SRS, 3% FSRT
- Mean dose was 14.8 Gy (9-30 Gy)
- 5-year PFS/OS were 33.6%/77.0%
- PFS better for Ki-67≤15
- Radiation necrosis rate of 12.5%



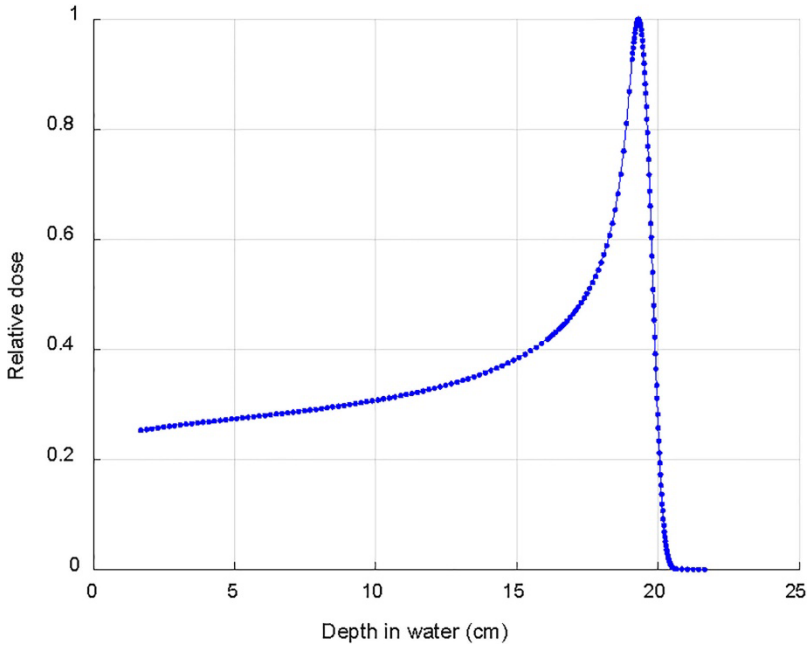
# at Risk			
Ki-67 ≤ 15	109	18	1
Ki-67 > 15	67	4	1



# at Risk				
Atypical	233	67	16	5
Anaplastic	38	12	4	1

Proton Therapy – Principles

- Utilize physical principle of Bragg peak to decrease dose to structures beyond target[30]
- Goal is decreased dose to nearby critical structures versus VMAT/IMRT
- Limited data looking specifically at proton therapy for meningioma
- Modern pencil-beam scanning may confer increased degree of benefit over protons than historical results using passive scattering[31]



30. Weber et al. "Proton Therapy for Intracranial Meningioma for the Treatment of Primary/Recurrent Disease Including Re-Irradiation." *Frontiers in Oncology* 10 (December 14, 2020): 558845. https://doi.org/10.3389/fonc.2020.558845.

Proton Therapy – Benefits

- Prospective data on protons for CNS tumors is sparse
- Outcomes primarily extrapolated from other disease sites, retrospective series, or using data from large databases
- Expected benefit of decreased secondary tumors in younger patients given long-term survival[32]
- Ability to spare hippocampi and pituitary with protons correlates with decrease incidence of cognitive impairment and endocrine deficiency[33,34]
- Biological modeling in patients with LGG has suggested up to 2x increased risk for secondary tumors with IMRT as compared to protons[35]

Proton Therapy – WHO Grade 1

- El Shafie et al. retrospective review of patients with skull-base meningioma (N=110)[36]
- WHO Grade I and unknown histology (93%) treated with scanning proton therapy
- Median dose was 54 Gy(RBE) [50-60 Gy(RBE)]
- 5-year PFS was 96.2% for WHO Grade 1/Unknown
- G3 toxicity in 4 patients, no G4-5 toxicity

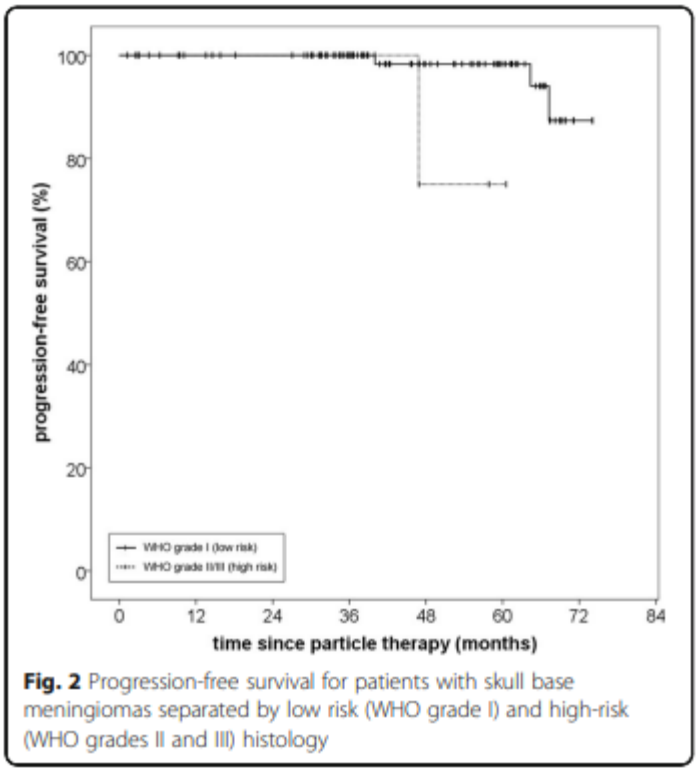


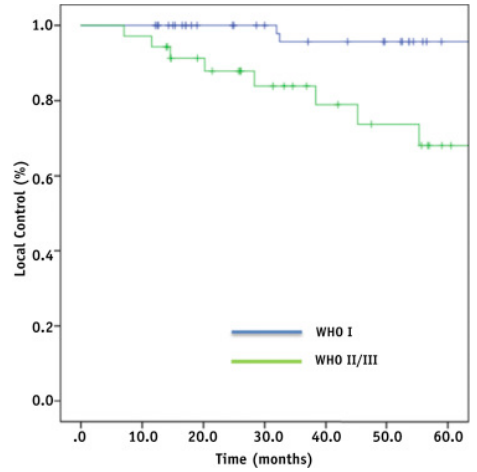
Fig. 2 Progression-free survival for patients with skull base meningiomas separated by low risk (WHO grade I) and high-risk (WHO grades II and III) histology

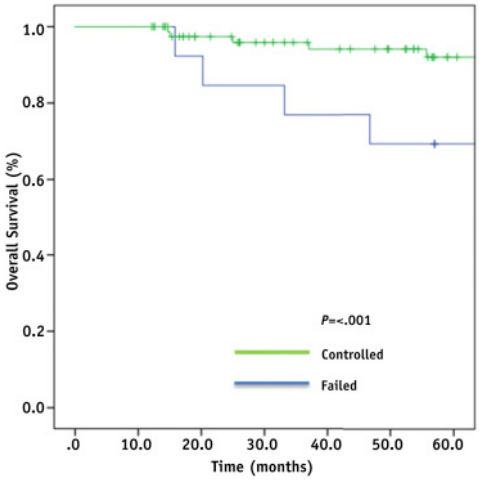
Proton Therapy – WHO Grade 1

Author	#Ref	Year	#pts	Median tumor∞/target volume⌂ (cm^3)[range]	Mean/median follow-up period (months)	Dose (GyRBE) (median/mean)	Delivery modality	Tumor outcome	Proton only	Visual toxicity# (%)	Brain necrosis‡ (%)
⌂⌂Vlachogiannis et al.	(20)	2017	170	⌂13.0 [1–64]	84.0	14–46 ¶ [21.9]	PSPT	PFS***: 85%	Yes	5/170 (2.9%)	5/170 (2.9%)
El Shafie et al.	(21)	2018	102	NR	46.8	50–60 [50.4]	Raster scanning	PFS**: 96.6%	Yes	0/102 (0%)	3/102 (2.7%)
Murray et al.	(22)	2017	61	∞ 21.4[0–547]○	56.9	50.4–56.0 [54.0]	PBS only	LC**: 95.7%	Yes	7/96¥ (7.3%)	3/96¥ (3.1%)
Noel et al.	(23)	2005	51	NR	25.4	54–64 [60.6]	PSPT only	LC**: 98%	No	0/51 (0%)	0/51 (0%)
⌂⌂Halasz et al.	(24)	2011	50	∞ 2.1[0.3–9.7]	32	10.0–15.5¶ [13.0]	PBS only	LC*: 94%	Yes	0/50 (0%)	2/50 (4%)
Slater et al.	(25)	2012	47	⌂27.6[1–224]	74.0	50.4–66.6	PSPT only	LC**: 99%	Yes	3/72¥ (4.2%)	2/72¥ (2.8%)
Wenkel et al.	(26)	2000	46	∞ 32[2–243]	53.0	53.1–74.1 [59.0]	PSPT only	RFS***: 88%	No	4/46 (8,7%)	4/46 (8.7%)
⌂⌂Vernimmen et al.	(27)	2001	23	⌂15.6[2.6–63]	40.0	54–61.6 17.3–24.3¶ [20.3] ¶	PBS only	LC**: 88%¶	Yes	0/27 (0%)	1/27 (3.7%)
Total # patients			**521**								
Median % LC/PFS (Range)								**96%** (85–99%)			
Median % Toxicity (Range)										**2.6%** (0.0–8.7%)	**3.4%** (0.0–8.7%)

Proton Therapy – WHO Grade 2-3

- Murray et al. retrospective review of meningioma patients treated with PBS protons (N=96)[37]
- Included WHO Grade 2 (34%) and Grade 3 (2%)
- 9/13 failures were in Grade 2-3 patients (all in recurrent or progressive setting; No failures were in upfront/definitive population)
- 8/13 failures were in-field
- 5-year LC for Grade 2-3 was 68%
- 5-year OS for Grade 2-3 was 81%
- 10% rate of G3 toxicity
- 1 G5 toxicity in patient with large (PTV 1032.8 cc) treatment volume





Proton Therapy – WHO Grade 2-3

Author	#Ref	Year	#pts	Median tumor∞/target volume⌓(cm³)[range]	WHOgrade	Mean/median follow-up period (months)	Dose (GyRBE) [median/mean]	Delivery modality	Tumor outcome	Protononly	Visual toxicity#(%)	Brainnecrosis‡ (%)
Murray et al.	(22)	2017	35	∞ 21.4[0–547] ○	II–III	56.9¶	54–68 [62.0]	PBS	LC**: 68.0%	Yes	1/35 (1.5%)	1/35 (2.9%)
Boskos et al.	(29)	2009	24	∞ 48.3[0–120]	II–III	32.2	0–34¥ 28.8–68¥¥ [68.0]	PSPT	LC**: 46.7%	No	0/24 (0%)	1/24 (4.2%)
McDonald et al.	(30)	2015	22	∞ 8.1[0–89.3]	II only	39.0	54–68.4 [63.0]	PSPT	LC**: 71.1%	Yes	0/22 (0%)	1/22 (4.5%)
Hug et al.	(31)	2000	16	NR	II–III	59.0Ø	40–72 [62–58] #	PSPT	LC**: 38–52%#	No	1/16 (6.3%)	1/16 (6.3%)
Total # patients			**97**									
Median % LC/ PFS (Range)									**52%** (38.0–71.1)			
Median % Toxicity (Range)											**0.8%** (0–6.4)	**4.4%** (2.9–6.3)

Proton Therapy – Indications[30]

Meningioma (WHO grade)	Treatment paradigm	Use of protons	Dose (GyRBE)	Level of evidence*	References
I (Benign)	Decrease in long term toxicity	Should be considered if clinically available for decreasing the probability of tumor induction	50.4–54	5	Bolsi et al. (43)
I (Benign)	Decrease in long term toxicity	Should be considered if clinically available for decreasing the probability of cognitive impairment	50.4–54	5	Florijn et al. (15)
II–III (Atypical/ Malignant)	Dose escalation for tumor control	Should be considered if clinically available	>54.0	3b	McDonald et al. (30), Hug et al. (31), Boskos et al. (29)
Recurring (I–III)	Tumor control and mitigate the risk of radiation-induced adverse events	Should be considered if clinically available and especially if: * Non-elderly patient * Initial Benign histology * Previous irradiation at <60 Gy	≤60 (retreatment)	4	Imber et al. (32) El Shafie et al. (21)

Oxford Centre for Evidence-Based Medicine. http://www.cebm.net/index.aspx?o=5653.

Ongoing Trials

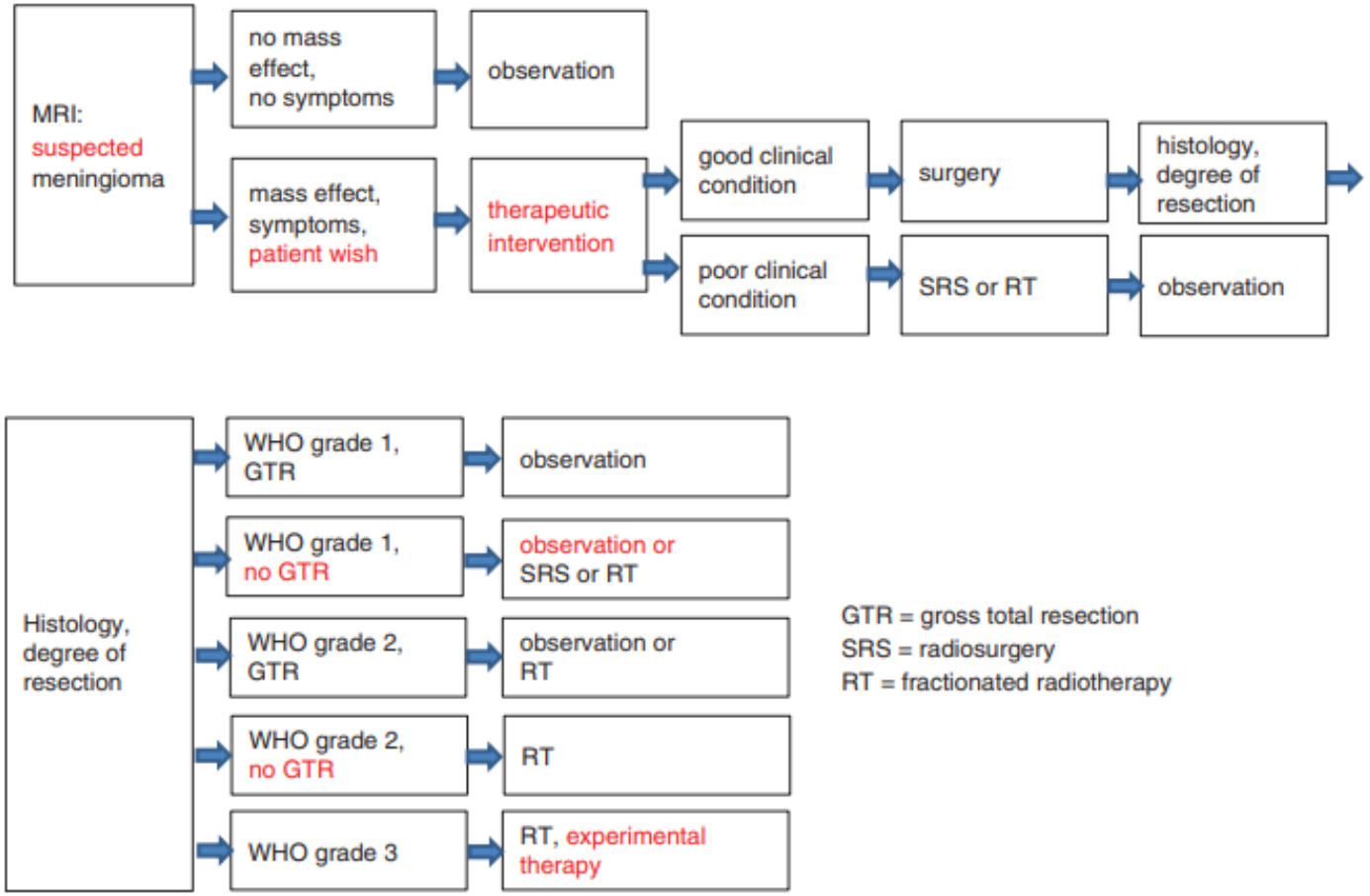
- **NRG BN003**[38]
  - Phase III RCT of observation versus adjuvant RT (59.4 Gy) following GTR for Grade 2 Meningioma
  - Primary endpoint: PFS
- **ROAM**[39]
  - Radiation versus Observation following surgical resection of Atypical Meningioma
  - RCT of observation versus adjuvant RT (60 Gy) following GTR for Grade 2 Meningioma
  - Primary endpoint: PFS

RT Dose Summary[40]

	WHO Grade 1	WHO Grade 2	WHO Grade 3
GTR	Observation	54-60 Gy/30fx *OR* Observation	59.4-66 Gy/30-33 Fx
STR	Observation *OR* 50.4-54 Gy/28-30 Fx *OR* SRS 12-14 Gy/1 Fx	59.4-60 Gy/30-33 Fx (SRS controversial)	59.4-66 Gy/30-33 Fx (SRS controversial)
Unresectable	50.4-54 Gy/28-30 Fx *OR* SRS 12-14 Gy/1 Fx	59.4-60 Gy/30-33 Fx *OR* SRS 14-18 Gy/1 Fx	59.4-66 Gy/30-33 Fx *OR* SRS 18-24 Gy/1 Fx

2016 EANO Guidelines[41]

EANO = European Association of Neuro-Oncology



Potential RT Toxicities

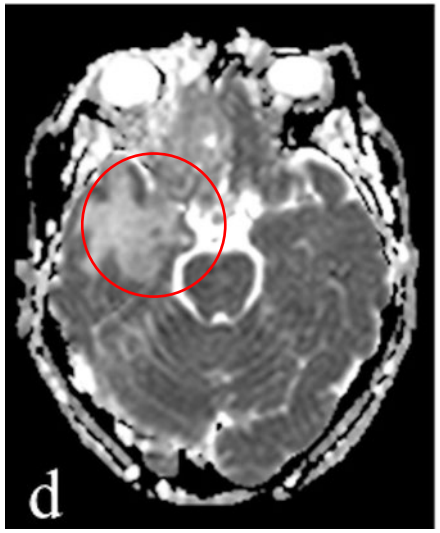
- **Acute**
  - Fatigue
  - Loss of appetite
  - Dermatitis/Alopecia
  - Nausea/Vomiting
  - Headaches
  - Transient worsening of preexisting symptoms
  - Encephalopathy
- **Chronic**
  - Radiation necrosis
  - Motor/sensory deficits
  - Neurocognitive changes
  - Vasculopathy/Stroke
  - Xerophthalmia/Retinopathy
  - Endocrinopathies
  - Secondary neoplasm
  - Migraine-Like Headache Syndrome (SMART)

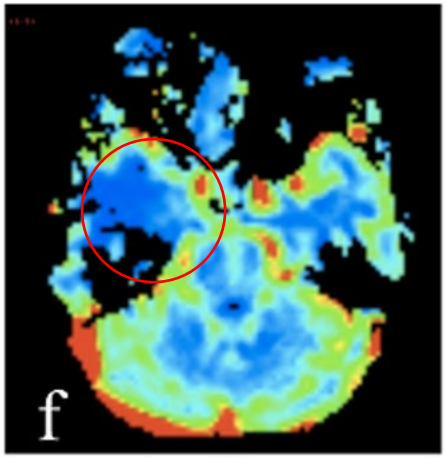
Protons & Radiation Necrosis

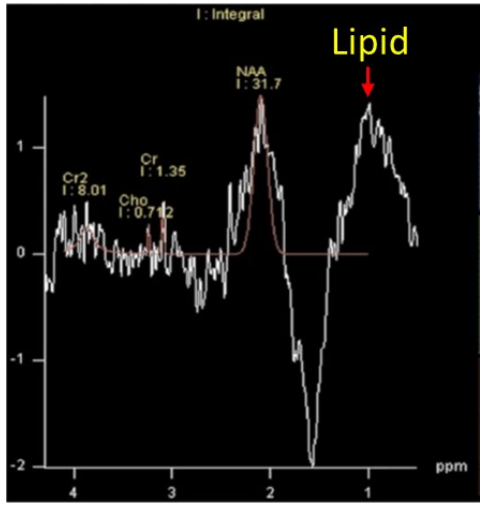
- Clinical dose conversion versus photons based on RBE = 1.1
  - **Conservative** estimate to ensure similar local control
  - LET increases with depth as protons decelerate -> Potential for increased RBE at distal edge of beam
- Reports have raised concern for radiation necrosis in patients with high 5y OS (meningioma, LGG) and pediatric patients with PF tumors (brain stem dose)[42,43]
- Unclear if this potential increase in LET/RBE leads to higher rates of radiation necrosis (conflicting evidence in literature)[42]
- Important to utilize advanced imaging (DWI, Spectroscopy, Perfusion) to differentiate between recurrence and necrosis
- Also important to consider location of suspicious enhancement in relation to distal beam edge (necrosis) and parameningeal areas (recurrence)

Radiation Necrosis Imaging[44]

- **DWI**
  - Less specific
  - Typically demonstrates high ADC
- **Spectroscopy**
  - Early: decrease in NAA and increase in Choline
  - Late: decrease in choline and NAA with increased lipid peak
- **Perfusion**
  - Transient increase in relative cerebral blood volume (rCBV)
  - Long-term decrease in rCBV

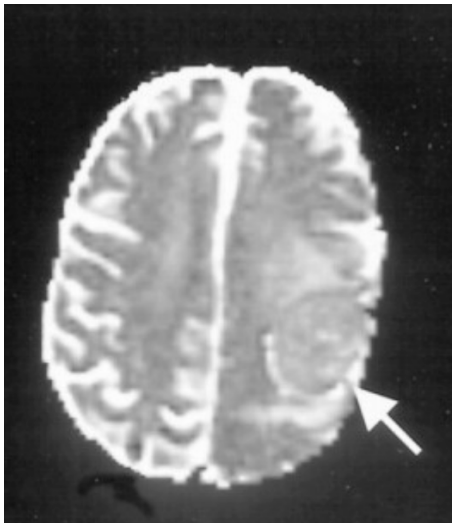


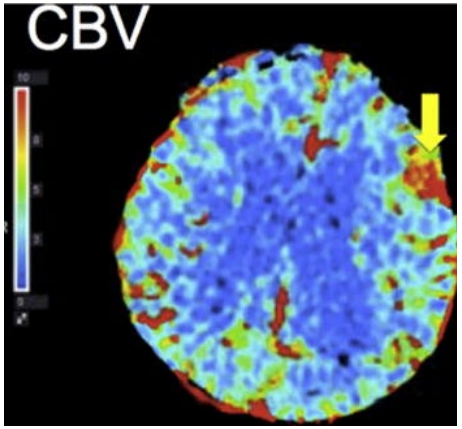


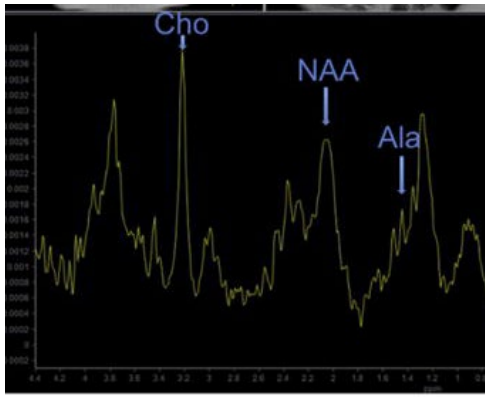


Recurrent Meningioma Imaging[45]

- **DWI**
  - ADC varies with histology[46]
  - Higher-grade -> Less intense
- **Spectroscopy**
  - Elevated Cho and decreased NAA
  - Prominent Ala more specific for meningioma
- **Perfusion**
  - Increase in rCBV







Radiation Necrosis Management[47]

- Asymptomatic:
  - Close surveillance (can spontaneously regress)
- Symptomatic:
  - **Corticosteroids**: 4-8 mg of dexamethasone daily (reduce cerebral edema)
  - **Bevacizumab** (anti-VEGF): either 7.5 mg/kg every three weeks or 5 mg/kg every two weeks x 4 cycles (can cause bleeding/HTN)
  - **Surgery**: Contraindication(s) to bevacizumab or diagnosis uncertain (tumor vs. necrosis)
  - **Other**: hyperbaric oxygen, laser interstitial therapy, antiplatelet therapy

Back to our case…

Postop. Course

- Gross total resection achieved showing WHO Grade 3 meningioma with papillary and focal chordoid features (25 mitoses/10 HPF)
- Postoperative course uneventful
- Seen in consultation in our department
- Patient was offered adjuvant PBS proton therapy due to young age
  - Technically, RTOG 0539 allowed protons only for intermediate risk patients
  - Benefits of PBS in this case felt to outweigh risks

Radiation Therapy Planning

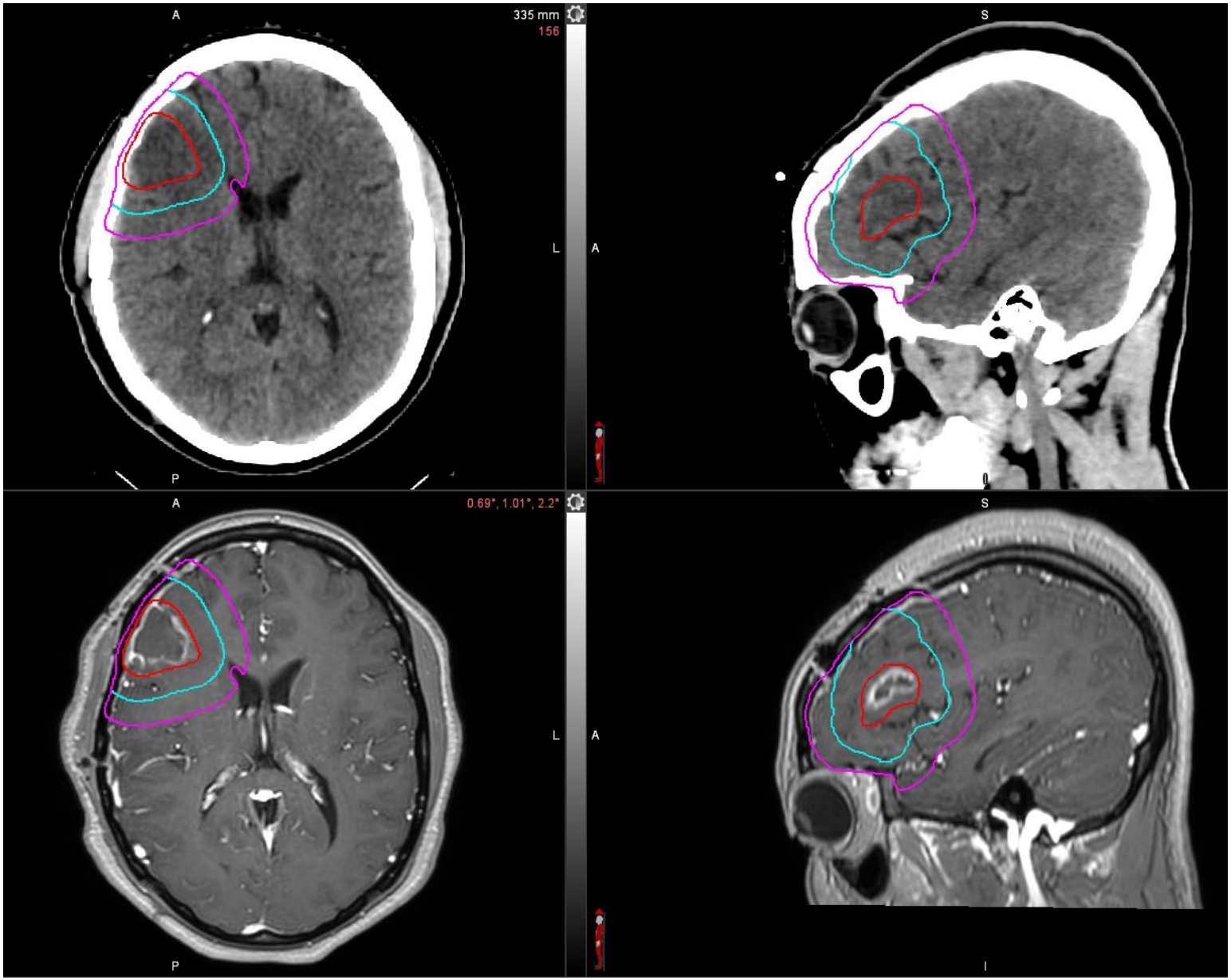
- Patient simulated chin-down for comfort and to facilitate treatment planning
- Contoured per RTOG 0539 protocol
  - **GTV**: Tumor bed + residual nodular enhancement
  - **CTV60**: GTV + 1.0 cm
  - **CTV54**: GTV + 2.0 cm
  - Margin decreased to 1.0 mm at anatomic barriers to tumor growth such as skull (matching CTV60)
- Robustness optimization used in lieu of PTV given treatment with PBS protons[48]
  - In photon planning, setup uncertainty is accounted for using a uniform PTV margin
  - In addition to setup uncertainty, proton plans also have range uncertainty (e.g., systematic range uncertainty of ~3% due to HU interpretation)
  - "Robustness optimization" is a specialized optimization process that accounts for range and setup uncertainties when generating a proton therapy plan
- Planned using a two-beam arrangement: right lateral and superior-inferior right anterior oblique (SIRAO)

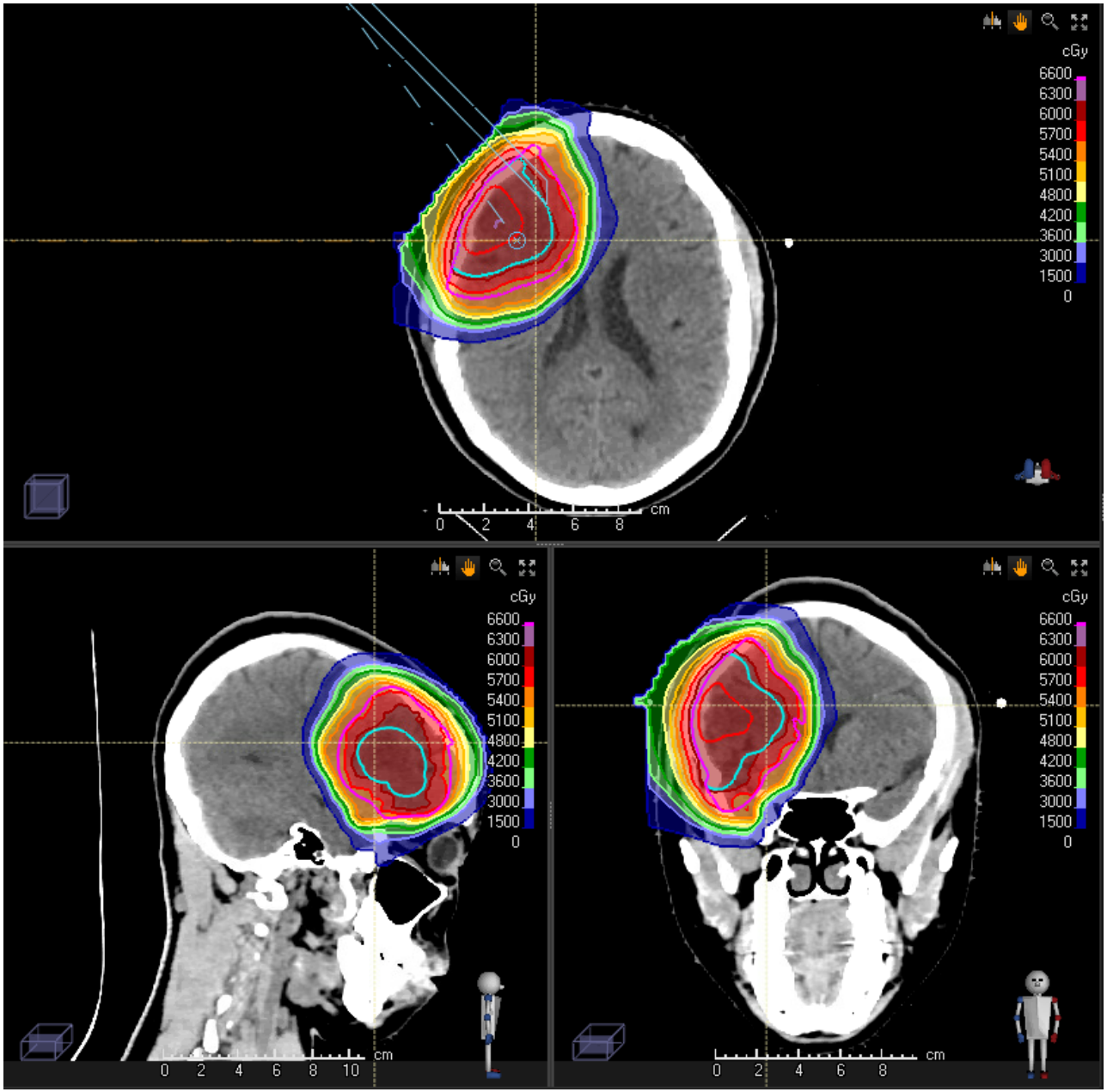
RTOG 0539[23]

Target Volume	Definition
GTV	Tumor bed on the postoperative-enhanced MRI + any residual nodular enhancement. Neither cerebral edema nor the "dural tail" are to be specifically included within the GTV.
CTV	Group II (CTV54): GTV plus a margin of 1.0 cm. Margin may be reduced to 0.5 cm around natural barriers to tumor growth such as the skull. Group III (CTV54 & CTV60): CTV60 is GTV plus a margin of 1.0 cm. CTV54 is GTV with a margin of 2.0. CTV54 margins may be reduced to 1 cm (thus corresponding to the PTV60) around natural barriers to tumor growth such as the skull.
PTV	Planning target volume (PTV) margins of 3.0-5.0 to account for uncertainties of daily set-up and localization. Reducing PTV margins to modify organ at risk (OAR) dose(s) is not generally permissible. However, organs at risk (OAR) must be defined, along with a planning risk volume (PRV) for each OAR. Each PRV will be its OAR plus 3.0 mm. In the event that an OAR is in immediate proximity to a PTV such that dose to the OAR cannot be constrained within protocol limits, a second PTV (PTVPRV), defined as the overlap between the PTV54 and the particular PRV of concern, may be created.

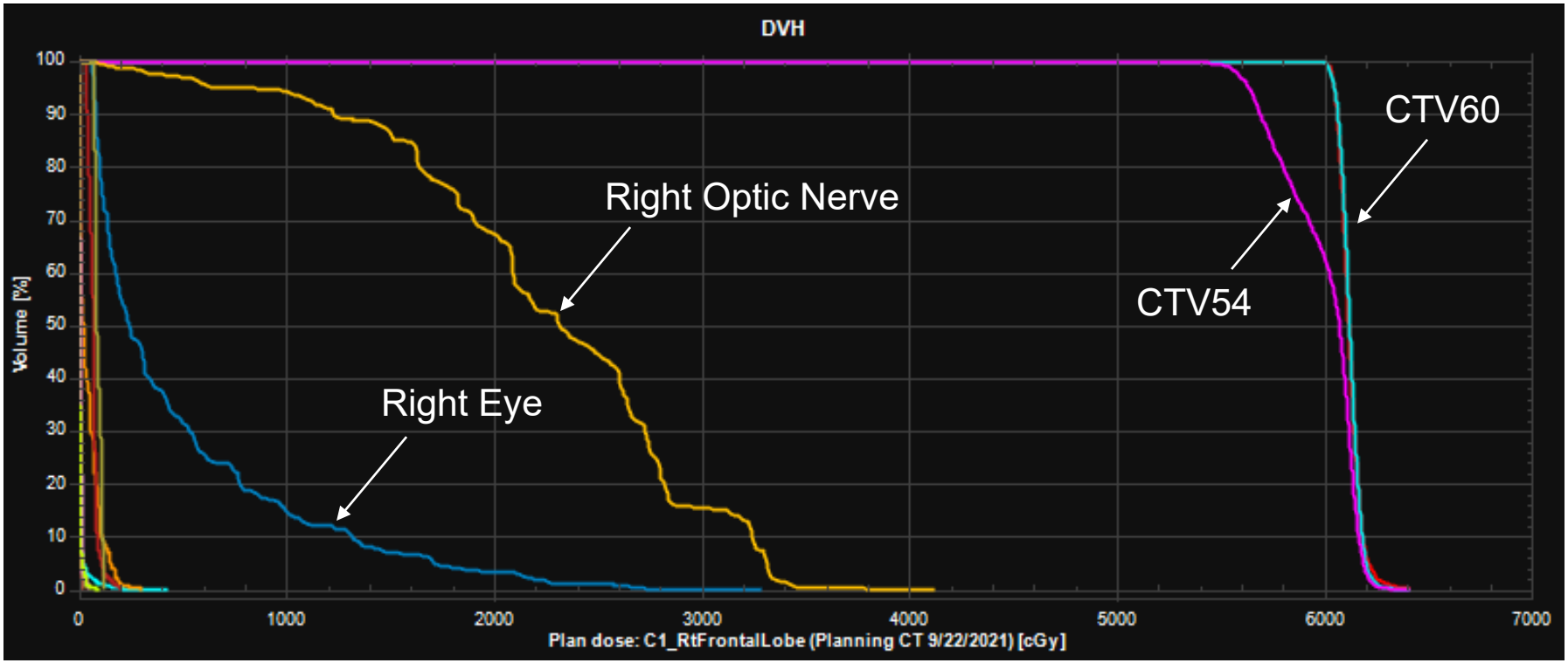
EORTC 22042-26042[26]

Target Volume	Definition
GTV	GTV delineated on co-registered MRI done before and after surgery defined as the visible tumor [region of enhancement on post-operative brain MRI (T1Gado+) and planning CT-scan (with iodine contrast)].
CTV	CTV1 (60Gy): GTV and/or sub clinical microscopic tumor (may include the pre-operative tumor bed, peritumoral edema, hyperostotic changes if any, and dural enhancement or thickening as seen in the CT/MRI at diagnosis) plus a 1.0 cm margin. CTV2 (70 Gy): GTV and/or sub clinical microscopic tumor plus a 5 mm margin.
PTV	PTV1 defined as the CTV1 plus a 5 mm margin (3 mm for SRT) to account for day-to day setup variation. The PTV2 defined as the CTV2 plus a 5 mm margin (3 mm for SRT) to account for day-to day setup variation. In patients with no visible tumor (i.e. Simpson 1-3), the GTV=CTV and estimated on the basis of the preoperative imaging demonstrating the meningioma attachment and the information in the surgeon's operative report on tumor attachment and microscopic tumor residue.


A
335 mm
156
L
A
P
S
I
A
0.69°, 1.01°, 2.2°
L
A
P
S
I


cGy
6600
6300
6000
5700
5400
5100
4800
4200
3600
3000
1500
0
cm
0 2 4 6 8
cGy
6600
6300
6000
5700
5400
5100
4800
4200
3600
3000
1500
0
cm
0 2 4 6 8 10
cGy
6600
6300
6000
5700
5400
5100
4800
4200
3600
3000
1500
0
cm
0 2 4 6 8

DVH


DVH
Volume [%]
100
90
80
70
60
50
40
30
20
10
0
0
1000
2000
3000
4000
5000
6000
7000
Plan dose: C1_RtFrontalLobe (Planning CT 9/22/2021) [cGy]
Right Optic Nerve
Right Eye
CTV60
CTV54

Treatment Planning

Our Patient:

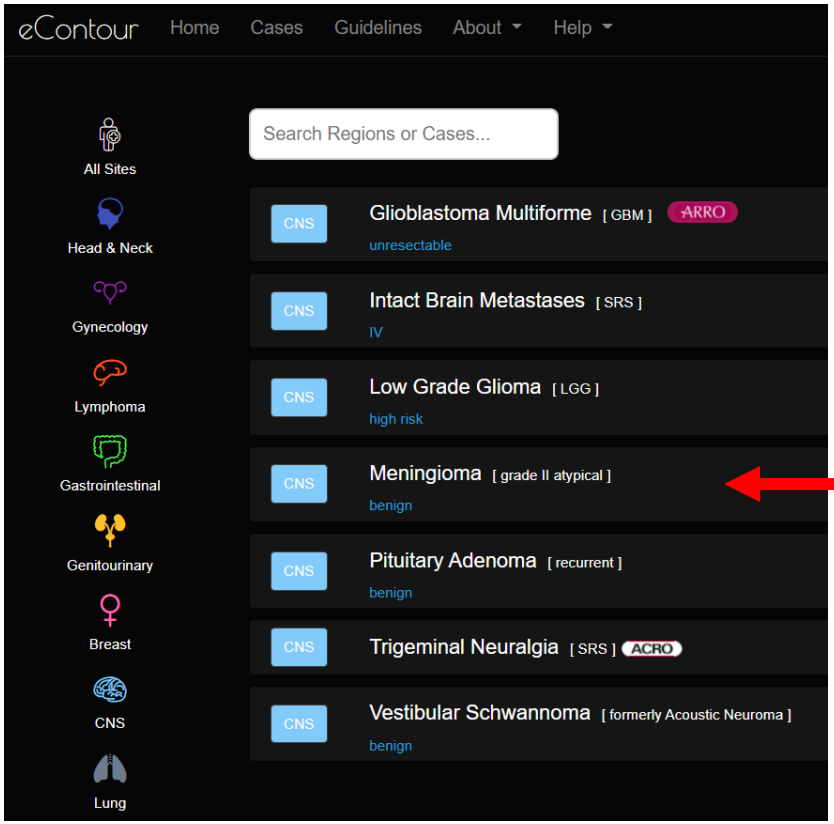
Structure	Goal	Achieved
GTV	V60 ≥ 100%	V60 = 100%
CTV_60	V60 ≥ 98%	V60 = 99.8%
CTV_54	V54 ≥ 98%	V54 = 99.8%
OpticNrv_L	Dmax < 54 Gy	Dmax = 1.01 Gy
OpticNrv_R	Dmax < 54 Gy	Dmax = 41.27 Gy
BrainStem	Dmax < 56 Gy	Dmax = 4.32 Gy
OpticChiasm	Dmax < 56 Gy	Dmax = 3.09 Gy
Pituitary	Dmax < 56 Gy	Dmax = 0.44 Gy
Lens_L	Dmax < 7 Gy	Dmax = 0.15 Gy
Lens_R	Dmax < 7 Gy	Dmax = 1.22 Gy
Eye_R	Dmax < 50 Gy	Dmax = 32.89 Gy
Eye_L	Dmax < 50 Gy	Dmax = 0.19 Gy
Cochlea_L	Dmean < 36 Gy	Dmean = 0 Gy
Cochlea_R	Dmean < 36 Gy	Dmean = 0.68 Gy

RTOG 0539:

Structure	Intermediate Risk	High Risk
Lenses	5 Gy	7 Gy
Retinae	45 Gy	50 Gy
Optic Nerves	50 Gy	55 Gy
Optic Chiasm	54 Gy	56 Gy
Brainstem	55 Gy	60 Gy

Example – eContour

- Representative case of Grade 2 disease
- Contoured per RTOG 0539
- https://econtour.org/cases/102



Follow-up

- Patient tolerated treatment well, experiencing only mild fatigue and intermittent nausea
- Clinically, her vision has returned to normal and her headaches have ceased
- 3- and 6-month follow-up MRIs demonstrated similar postoperative changes without evidence of disease recurrence

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Feedback

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