Benign Meningioma

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Dedicated to mentor and friend Dr. Moody D. Wharam, the embodiment of Aequanimitas

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Contents

2.1 General Principles of Simulation and Target Delineation (Tables 2.1 and 2.2, Fig. 2.2)

- CT simulation in a thermoplast mask at zero angulation.
- Diagnostic CT to evaluate bone invasion requiring inclusion in GTV.
- Volumetric 3D reconstructed thin slice (1.5 mm optimal) MRI with T1 pre-gadolinium and fat-suppressed post-gadolinium, with 3D reconstruction for target delineation. T2 and FLAIR may assist evaluation of dural/calvarial involvement.
- Enhancing lesion on T1 with contrast, bone invasion, and tumor-adjacent dura at risk are targets.

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Table 2.1 Suggested target volumes for conventional fractionation

Target volumes	Definition and description
GTV	T1-enhancing tumor all planes on MRI, bone invasion (use MR + bone windowing on CT). Do not include brain parenchymal edema, which may be present with some low-grade lesions. True brain invasion upgrades lesion to atypical (see chapter on atypical meningioma)
CTV	3–5 mm along proximal dura at risk. May or may not include dural tail (see Fig. 2.1, general principles.) May modify based on clinical/anatomical factors. Exclude brain parenchyma
PTV	3–5 mm per machine/setup specifications

Table 2.2 Suggested target volumes for SRS

Target volumes	Definition and description
GTV	Enhancing lesion on T1 + C all planes
CTV	N/A
PTV	N/A

Note: CTV = GTV for stereotactic radiosurgery (SRS)

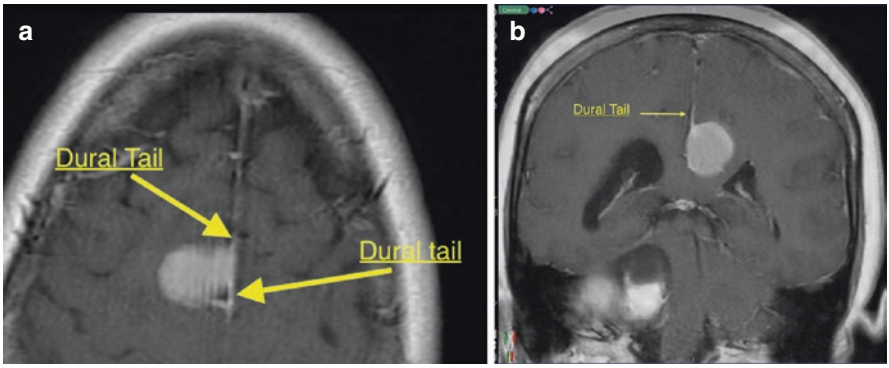

Fig. 2.1 Axial and coronal slices of benign parasagittal meningiomas of the right frontal lobe (Image **a**) and left parietal lobe (Image **b**). A dural tail extends anteriorly and posteriorly and superiorly and inferiorly along dura, respectively. The dural tail is a radiographic finding reflecting hypervascular dura that may or may not harbor tumor cells. All tumor-adjacent dura is at risk of harboring microscopic tumor cells [8], and the "dural tail" is at no higher or lower risk of relapse than other tumor-adjacent dura

- Fuse MR with CT. If postoperative case, fuse preoperative and postoperative imaging.
- Incorporate reconstructed thin-sliced coronal and sagittal MR cuts to help identify and assure three-dimensional coverage of region at risk.
- Distinguish *dural attachment* (tumor) from *dural tail*, which is predominantly hypervascular tissue that may or may not harbor tumor cells along with all tumor-adjacent dura [1].

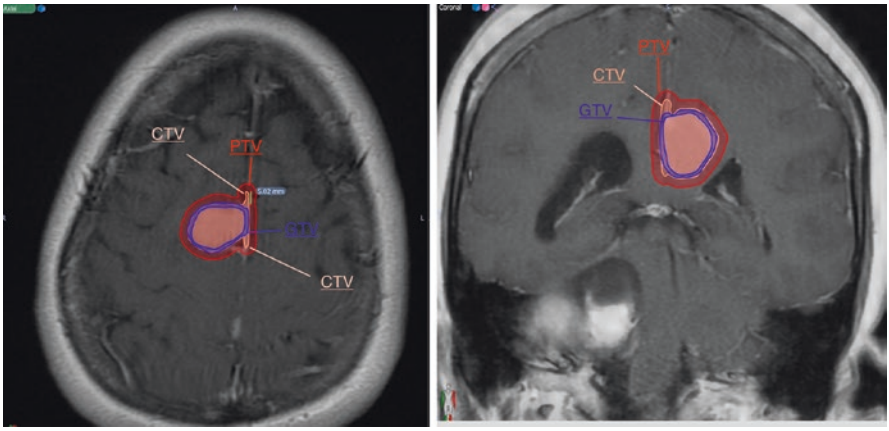

Fig. 2.2 Sample contouring for right frontal and left parasagittal meningioma. The gross tumor is designated as GTV outlined by blue. CTV indicated by peach extends along adjacent dura but not into normal brain parenchyma, which is not at risk of invasion in benign meningioma. Note that the 5 mm CTV margin acknowledges that all tumor-adjacent dura is at risk, regardless of the presence of hypervascular dural tail. Thus, the entirety of dural tail may or may not be included in the CTV, and the CTV should not be reduced along tumor-adjacent dura because of radiographic absence of a dural tail. Care should be taken to distinguish frank meningioma from dural tail with neuroradiologic consultation. CTV should be modified based on all relevant clinical information to incorporate volumes likely to harbor subclinical/microscopic disease. PTV indicated by red is determined by the immobilization and machine setup and localization parameters. Note, for stereotactic radiosurgery, no margin is added to GTV (i.e., CTV = GTV). This targeting paradox is an area of controversy in the management of meningioma [1, 10]. The parasagittal location of both these lesions favors conventional fractionation [2–4]

- If MRI is contraindicated, use thin slice CT (1.0 mm slices) with and without contrast.
- 3D conformal RT, IMRT/VMAT, SRS, and proton therapy may be considered.
- If optic structures or the pituitary abut tumor and/or likely to be in meaningful dose gradient, recommend pretreatment neuro-ophthalmology and endocrine consult, respectively, to assess baseline function. Patient may be at risk for life-threatening adrenal insuffiency over time, along with other endocrinopathies.
- Keep in mind dose-gradient and setup uncertainty when considering SRS in proximity to critical structures.

2.2 Clinical Pearls

- Parasagittal/parasinus lesions are high risk (~25–45%) for post-radiosurgical symptomatic edema requiring medical intervention. Consider conventional fractionation rather than SRS for these lesions [2–4].
- If patients require steroids >3–4 weeks, consider *Pneumocystis jiroveci* pneumonia prophylaxis.
- Consider trial of celecoxib in lieu of/in aid of tapering steroid for patients not tolerating/requiring long-term dexamethasone if not otherwise contraindicated.

- Consider the association of long-term local control with extent of surgical resection/dural stripping [5] when determining region "at risk" (CTV) in radiation treatment planning.
- Low-grade meningioma has a propensity for late relapse. ~50% of patients with "low-risk" lesions die a cause-specific death with extended follow-up of 25 years [6].
- Relapse is associated with subsequent aggressive behavior regardless of up-front treatment [6, 7].
- Data with long-term (≥10 years) median follow-up for SRS is limited. Actuarial data for disease with a propensity for late relapse tends to underestimate recurrence rates.

1. Dose Prescriptions
   - For conventional fractionation: 54 Gy in 30 fractions (1.8 Gy/day), may dose paint to limit normal critical tissue (such as chiasm) to 50.4 Gy.
   - For stereotactic radiosurgery (SRS): 12–14 Gy in a single fraction, respecting normal tissue tolerances.

2.3 Treatment Planning Techniques (Tables 2.3 and 2.4)

- *Conventional fractionation*: 3D CRT, IMRT, VMAT, and protons may all be used with the goal of minimizing dose to brain/critical structures. Dose painting may be necessary (i.e., 54 Gy to most of CTV, limiting critical structure such as optic nerve to 50.4). Mindful of dose to the pituitary, brain stem, cord, cochlea, and cranial nerves, considering long-term survival of most patients. Tolerance of critical structures compromised from baseline if they have been previously injured by tumor encroachment and/or surgical manipulation.
- *SRS*: Data is retrospective and/or median follow-up of <10 years. Actuarial data tends to under-estimate risk of relapse for disease entities with a propensity for late failure. Be wary of outcome curves past median follow-up. Risk for symp-

Table 2.3 Recommended normal tissue constraints for 1.8 Gy/day fractionation schemes

Organs at risk	Suggested dose constraints
Optic nerves and chiasm	<54 Gy [11]
Retinae	<45 Gy [12]
Lenses	<10 Gy [13]
Lacrimal glands	<30 Gy, mean <25 Gy [14, 15]
Pituitary gland	Beam angles/planning techniques to minimize dose to the pituitary
Cochlea	≤35 more conservatively (may escalate to ≤45 so as to not sacrifice coverage of target) but keep as low as possible as no lower threshold for sensory-neural hearing loss determined [16]
Brain stem	≤54 Gy in 1.8 Gy fractions [17]

Table 2.4 Recommended normal tissue constraints for radiosurgery

Object at risk	Suggested dose constraints
Optic nerves and chiasm	<8–12 Gy [18]
Pituitary gland	Beam angles and planning techniques to minimize dose to the pituitary
Cochlea	Keep ≤12 Gy [16]
Brain stem	Keep ≤12 Gy [17]

Table 2.5 Side effects

Acute	Common: Hair loss, fatigue. Less common: headaches, nausea, and inflammation/cerebral edema causing neurological symptoms, often exacerbation of presenting symptoms
Long-term	Cranial nerve deficit, neurocognitive decline and hypopituitarism, subacute symptomatic edema requiring steroids, related to anatomical region treated and dose-fractionation scheme used
Uncommon or rare risks	New onset seizure, vision loss, hearing loss, cranial nerve injury, hemorrhage, necrosis, stroke secondary malignancies

tomatic edema after radiosurgery may be as high as 25–45% for parasinus/parasagittal lesions [2–4, 9].

Side effects. Please see Table 2.5.

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