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# Neurosurgical management of brain metastases

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## Overview of current treatments

Before the 1990s, whole-brain radiation therapy (WBRT) remained the standard treatment of brain metastases (BMs).[1] However, a seminal study by Patchell et al prospectively compared surgical resection followed by WBRT vs WBRT alone in patients with a single BM. Patients who received surgery and radiation had significantly longer overall survival, lower rates of local recurrence, and better quality of life.[2] WBRT is rarely used as initial monotherapy for fewer than 4 BMs given the cognitive sequelae, negative effect on lifestyle, and lack of survival benefit.[3-6] Therefore, surgical resection and stereotactic radiosurgery (SRS) with or without adjuvant WBRT remain the primary neurosurgical management strategies for BMs.

Lesions that cause neurologic deficits, have symptomatic mass effect, or significant edema are candidates for surgical resection. Surgical resection also provides the added benefit of obtaining diagnostic tissue.[7] Gross total resection is the goal when treating metastatic lesions. Frameless stereotaxy is often used during surgery, but a recent trial has demonstrated that frameless neuronavigation does not influence extent of resection.[8] For lesions in eloquent locations, functional data can be incorporated into neuronavigation, namely functional magnetic resonance imaging (MRI) and diffusion tension imaging. Functional MRI can be used to localize both cortical and subcortical eloquent areas and diffusion tension imaging can aid in delineating the relationship of the lesion to important subcortical fiber tracts.[9,10] Tractography can influence preoperative planning and lead to modification of the surgical approach.[11] Advanced neuronavigation and intraoperative neuromonitoring are methods that can aid in resecting lesions in areas that were previously not considered for surgery.[12]

Focused irradiation via single-fraction SRS is another treatment of metastatic lesions that has demonstrated survival advantage in comparison with WBRT alone.[13,14] Many patients present with lesions for which either surgery or SRS is an option. For solitary BM management, survival does not significantly differ between surgical resection and SRS. However, SRS is associated with lower frequency of adverse events and improved local control when compared with surgery alone.[15]

Single-fraction SRS is limited by the inability to deliver adequate dose to larger lesions. The ideal treatment modality of most larger lesions (maximum diameter $>3$ cm) is surgical resection.[16] In locations that are not amenable to surgery, such as the brainstem, SRS can be

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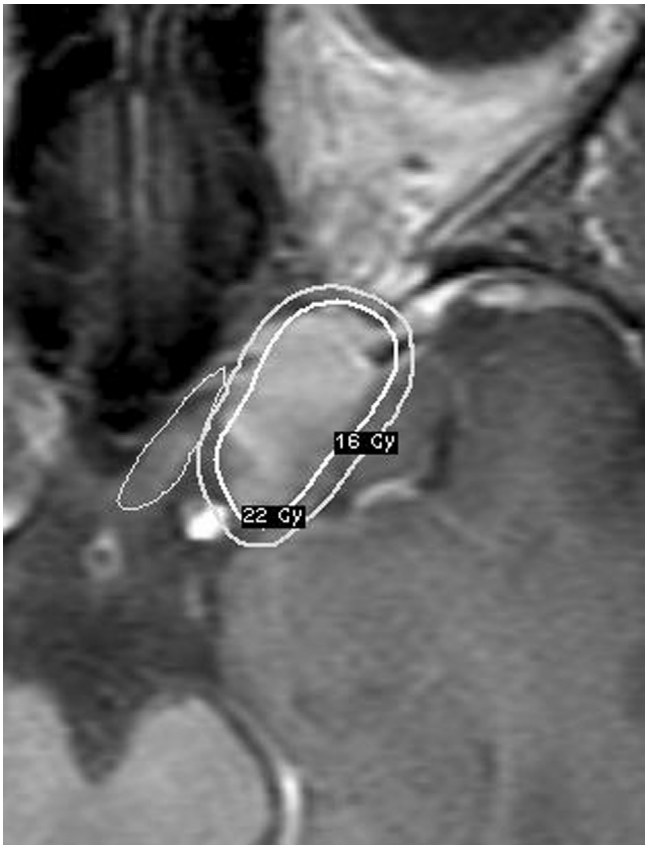


**Fig. 1.** Hypofractionated stereotactic radiotherapy (SRT). Gadolinium-enhanced SRT treatment planning MRI of a malignant meningioma metastasis to the left cavernous sinus. A marginal dose of 22 Gy to the 50% isodose line was delivered in 4 fractions. The outlined left optic nerve is outside the 16 Gy isodose line and receives less than 4 Gy per fraction, well within its expected tolerance. Optic nerve tolerance for single-fraction SRS is only 8-10 Gy, precluding treatment of this lesion with single-fraction SRS. This tumor was refractory to conventionally fractionated radiation.

used.[17-19] For patients with large metastases (10-55 mL) in unfavorable locations or those with other strong contraindications to surgery, other alternatives are needed. Hypofractionated stereotactic radiotherapy is an option for such patients although the optimal dose and fractionation are not yet known (Fig 1).[20,21] For these large lesions (Fig 2), 2-session SRS can also be used. Recent reports of 2-session SRS delivering a median of 14 (range: 10-18 Gy) Gy 3-4 weeks apart for a total of 28 Gy (range: 20-30) suggest that this may prove to be a viable option for patients with particularly challenging large lesions.[22,23]

SRS as upfront monotherapy can lead to excellent local control. For non – small lung cancer, the most common cancer to metastasize to the brain, local control rates have varied from 50%-94% in patient series.[24-27] The dose of SRS is correlated to local control rates and overall survival. The 20-Gy dose leads to improved outcome in comparison with 16-18.5 Gy when treating brain metastatic lesions in patients with breast cancer.[28] For patients who undergo SRS as primary monotherapy, minimum SRS dose as well as histology, systemic disease, and number of metastases has been found to be predictive of failure and progression to WBRT.[29] Salvage therapy following local failure of SRS can include WBRT or surgical resection. For these patients who have failed SRS, subsequent surgical resection with carmustine wafer implantation has shown promise.[30]

Approximately half of patients with intracranial metastatic disease will present with more than 1 lesion. WBRT alone does not prove durable with local failure of up to 100% at 1 year.[31]