



## An Overview on the Role of MRI in Diagnosis and Management of Brain Tumors

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### ABSTRACT

In brain tumors, the advanced treatment options techniques mostly depend on radiotherapy and neurosurgery, it also revolves around several factors including the type of tumor, extent, and location that are demonstrated by modern magnetic resonance imaging and positron-emission tomography scan. These modalities have high variability and lack method standardization application. The objectives of this review are to present an overview of many evidence-based published studies on neurosurgical and radiotherapeutic management of brain tumors. This review had a wide-ranging research literature strategy. PubMed electronic databases were the basic citation resources. Initially, the management of brain tumors should be analyzed by a multidisciplinary team (radiation oncology, medical oncology, and neurosurgery) based on the mentioned factors affecting the condition. In Whole brain radiotherapy radiologists are serving as a basic component in the primary treatment for brain metastases in patients with expected higher survival rates and lower recurrence after stereo static resection surgery. The alternative for WBRT is performing hypofractionated radiation therapy, in cases that are not susceptible to perform radiosurgery or surgery. However, dosing in hypofractionated radiation therapy is still controversial.

**Keywords:** Brain tumor, Imaging, Magnetic resonance, Radiotherapy

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### INTRODUCTION

Since the 1980s computed tomography modalities have been replaced by modern magnetic resonance scanners as diagnostic and method of choice in detecting brain metastatic tumors (Hassan *et al.*, 2019; Moayeri *et al.*, 2020). Magnetic resonance scanners have greatly evolved throughout the years, with noticeable digital and hardware improvements, including more competent gradients and accelerating magnetic field, as well as software modification, including additional evolutionary pulse sequences and more expanding imaging post-processing techniques involving analysis capabilities and extraction of the quantitative data. Now, magnetic resonance scanners, spectroscopes, and other imaging techniques have been used to collect information on intracranial tumors and metastases. There are other advanced imaging tools involving magnetic resonance imaging (MRI), spectroscopy, and positron emission

tomography scan (PET) are known to help differentiate the tumor's metastatic stages and distinguish radiation necrotic abilities from an effective treatment (Pope, 2018).

In brain tumors, the advanced treatment options techniques mostly depend on radiotherapy and neurosurgery, it also revolves around several factors including the type of tumor, extent, and location that are demonstrated by modern magnetic resonance imaging and positron-emission tomography scan. These modalities have high variability and lack method standardization application (Langen *et al.*, 2017; Kocher *et al.*, 2020). Initially, the management of brain tumors should be analyzed by a multidisciplinary team (radiation oncology, medical oncology, neurosurgery) based on the mentioned factors affecting the condition (Perkins & Liu, 2016).

The purpose of this review is to contribute and focus on standard radiological imaging modalities in the neurosurgical and radiotherapeutic management of brain tumors and provide a helpful practical and clinical guide of current physiological and anatomical imaging in brain tumors radiological findings.

## MATERIALS AND METHODS

This review had a wide-ranging research literature strategy. PubMed electronic databases were the basic citation resources. Every collected data that is discussed in this review is collected and summarized from the year 1989 to 2020. The following keywords were used in combination on Mesh providing these search terms: ((“Brain”[Mesh] AND “Tumor” [Mesh] AND “MRI” [Mesh] “Radiotherapy” [Mesh] “Radiosurgery” [Mesh] AND “Planning” [Mesh])). Only published English documents, articles, clinical trials, and reviews were involved in this overview.

### Review

#### Brain tumors and radiography

Many decades ago, Magnetic resonance imaging (MRI) was destined to point out delineation in brain tumors, as every suspected patient with intracranial tumors must undergo the initial assessment that involves magnetic resonance imaging. Thus, it was performed throughout a radio-oncologists routine to outcast false senses of serious familiarities regarding intracranial tumors. The distortions presented in magnetic resonance images explain the complicated relationship between radiotherapy and MRI, which sometimes might overshoot predicted treatment errors introduced by magnetic resonance imaging (Kondziolka *et al.*, 1992; Pötter *et al.*, 1992; Sumanaweera *et al.*, 1994; Khoo *et al.*, 1997; Putz *et al.*, 2020). Today, multimodality therapeutic approaches including both radiotherapeutic, surgical, and in some cases undergoing adjuvant chemotherapy, are considered as the golden standard for demonstrating and evaluating the malignant brain tumor. This demonstration can be beneficial regarding notable survival advantages (Stupp *et al.*, 2005; Cheng *et al.*, 2014; Khatko & Kolodina 2021). These survival advantages are specifically maintained on patients with alarming headache symptoms who require emergent imaging (**Table 1**) (Purdy & Kirby, 2004; Perkins & Liu, 2016).

**Table 1.** Alarming headaches that require emergent brain imaging (Purdy & Kirby, 2004; Perkins & Liu, 2016)

Newly changes prior headaches that are acute to severe
Systemic symptoms association such as fever
Elderly patients who are older than 50 years
Constant changing in the time of occurrence especially in the early morning or at night
Patients with meningismus
Patients developing new neurological signs
Valsalva maneuver precipitates pain
Lesions that are progressive
Older or younger patients complaining of persistent severe headaches

#### Understanding advanced imaging and workup

Initially, the management of brain tumors should be analyzed by a multidisciplinary team (radiation oncology, medical oncology, neurosurgery) based on the mentioned factors affecting the condition (Perkins & Liu, 2016). However, radiologists have

greater capabilities in detecting tumors and their metastatic performance. The interpretation of radiological magnetic scans is one of the basic principles underlying physiologic imaging techniques (**Table 2**) (Pope, 2018).

**Table 2.** Biomarkers associated with MRI physiological applications in brain metastatic neuroimaging: (Pope, 2018)

Techniques	Biomarkers	Correlations
Diffusion-weighted imaging (DWI)	Acquired apparent diffusion Joint efficiency	Cytotoxicity, vasogenic edema and cellularity.
Arterial spin labeling (ASL)	Cerebral blood circulation flow	Vascularity
Diffusion tensor imaging (DTI)	Mean diffusion and fractional anisotropy	White matter tracts disruption
Dynamic susceptibility contrast (DSC)	Volume of relative cerebral blood mean transient time	Capillary proliferation, angiogenesis
Dynamic contrast-enhanced (DCE)	(Ktrans) coefficient contrast transfer	Capillary permeability

#### Radiotherapeutic planning

##### MRI sequences in stereotactic radiotherapeutics planning

Initially, using magnetic resonance imaging for radiotherapy planning demands the accuracy of the (GTV) tumor gross volume delineation in a three-dimensional space. The best modality suited for the task is isotropic 3D- sequencing, they minimize the tumor gross volume over-or underestimation due to the volume partial effects. Moreover, unlike 2D sequences, the 3D sequence continuously images the brain without gaps as it's known to be less susceptible to distortions related to B0 inhomogeneity (Putz *et al.*, 2020; AlShehri *et al.*, 2021).

If the tumor gross volume exceeds 10%, this indicates a volumetric error and is usually presented on less than 5 slices, especially in small brain metastases. However, partial volume effects are affected by the thickness of the slices and this leads to an overestimation of the tumor gross volume. Partial volume effect accumulation is required to be evaluated upon the fusion of multiple MRI series reordered on coronal or sagittal planes as it leads to inaccurate contouring of the tumor gross volume. Experiencing image gaps and thick slices can affect tumor gross volume estimation or might miss any small metastases happening (Snell *et al.*, 2006; Putz *et al.*, 2020; Mojahed *et al.*, 2021).

3D magnetic resonance imaging technique has mostly used the T1-MPRAGE sequence in evaluating brain tumors and has also been included as a golden standard in the brain tumor imaging protocols. T1-SPACE (3D- turbo-spin-echo) is highly recommended for frequent use in intracranial radiotherapy, unlike the T1-MPRAGE gradient-echo sequence (Danieli *et al.*, 2019; Putz *et al.*, 2020). Regarding the contrast agent between white and grey matter, T1-SPACE helps the delineation of metastases and suppresses the vessels as it implements less contrast, unlike T1-MPRAGE where underestimation of the tumor boundaries might happen due to low uptake of the contrast agent (Komada *et al.*, 2019; Putz *et al.*, 2020).

#### *Stereotactic radiotherapy time intervals and administration of the contrast agent*

MR imaging in radiotherapeutic planning needs to be addressed in further researches. The requirements in MR imaging in routine diagnosis differs from imaging radiotherapy, the radiologists are meant to discuss different aspects and highlight important topics related to the situation. These topics must address free imaging distortions, the time interval between images, and the treatment using a 3D sequence (Putz *et al.*, 2020).

#### *WBRT- Whole brain radiotherapy*

Whole-brain radiotherapy is serving as a basic component in the primary treatment for brain metastases in patients with expected higher survival rates and lower recurrence after stereo static resection surgery. However, the noticeable toxicity of whole-brain radiotherapy is undeniable in long-term sequelae and can highly impact the patient's quality of life. Moreover, several clinical trials were conducted showing serious cognitive decline that was reported (Kotecha *et al.*, 2018). About 5% of the patients were presented with debilitating dementia, urinary incontinence, and gait ataxia (DeAngelis *et al.*, 1989). To reduce WBRT toxicity there were significant advances in the testing and development of the technological and pharmacological design, by receiving memantine (Kotecha *et al.*, 2018).

#### *Hypofractionated radiation therapy*

The alternative for WBRT is performing hypofractionated radiation therapy, in cases that are not susceptible to perform radiosurgery or surgery. Hypofractionated radiation therapy is known to have good lesion control and an acceptable toxicity profile. The dosing in hypofractionated radiation therapy is still controversial (Masucci, 2018).

### CONCLUSION

Initially, the management of brain tumors should be analyzed by a multidisciplinary team (radiation oncology, medical oncology, neurosurgery) based on the mentioned factors affecting the condition. Using magnetic resonance imaging for radiotherapy planning demands the accuracy of the (GTV) tumor gross volume delineation in a three-dimensional space. The best modality suited for the task is isotropic 3D- sequencing, they minimize the tumor gross volume over-or underestimation due to the volume partial effects. The requirements in MR imaging in routine diagnosis differs from imaging radiotherapy, the radiologists are meant to discuss different aspects and highlight important topics related to the situation. In Whole brain radiotherapy radiologists are serving as a basic component in the primary treatment for brain metastases in patients with expected higher survival rates and lower recurrence after stereo static resection surgery. The alternative for WBRT is performing hypofractionated radiation therapy, in cases that are not susceptible to perform radiosurgery or surgery. However, dosing in hypofractionated radiation therapy is still controversial.

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### REFERENCES

- AlShehri, K. M., Alqahtani, W. S., Alqahtani, I. S., Albalawi, M. A., Alotaibi, N. M., & Alahdal, K. Y. (2021). Laser-assisted removal of all-ceramic restorations: A systematic review. *Annals of Dental Specialty*, 9(3), 45-50.
- Cheng, Y., Morshed, R. A., Auffinger, B., Tobias, A. L., & Lesniak, M. S. (2014). Multifunctional nanoparticles for brain tumor imaging and therapy. *Advanced Drug Delivery Reviews*, 66, 42-57.
- Danieli, L., Riccitelli, G. C., Distefano, D., Prodi, E., Ventura, E., Cianfoni, A., Kaelin-Lang, A., Reinert, M., & Pravata, E. (2019). Brain tumor-enhancement visualization and morphometric assessment: A comparison of MPRAGE, SPACE, and VIBE MRI techniques. *American Journal of Neuroradiology*, 40(7), 1140-1148.
- DeAngelis, L. M., Delattre, J. Y., & Posner, J. B. (1989). Radiation-induced dementia in patients cured of brain metastases. *Neurology*, 39(6), 789-789.
- Hassan, E. A., Alhadidy, A. E., Elgohary, T., Farouk, K. H., & Henein, A. (2019). Effect of targeted temperature method on the ICU length of stay for traumatic severe brain injury patients. *Journal of Advanced Pharmacy Education & Research*, 9(1), 1-5.
- Khatko, Z. N., & Kolodina, E. (2021). Pectin-containing flour confectionery with a reduced gluten content. *Journal of Biochemical Technology*, 12(3), 9-13.
- Khoo, V. S., Dearnaley, D. P., Finnigan, D. J., Padhani, A., Tanner, S. F., & Leach, M. O. (1997). Magnetic resonance imaging (MRI): Considerations and applications in radiotherapy treatment planning. *Radiotherapy and Oncology*, 42(1), 1-15.
- Kocher, M., Ruge, M. I., Galldiks, N., & Lohmann, P. (2020). Applications of radiomics and machine learning for radiotherapy of malignant brain tumors. *Strahlentherapie und Onkologie*, 196(10), 856-867.
- Komada, T., Naganawa, S., Ogawa, H., Matsushima, M., Kubota, S., Kawai, H., Fukatsu, H., Ikeda, M., Kawamura, M., Sakurai, Y., et al. (2008). Contrast-enhanced MR imaging of metastatic brain tumor at 3 tesla: Utility of T1-weighted SPACE compared with 2D spin echo and 3D gradient echo sequence. *Magnetic Resonance in Medical Sciences*, 7(1), 13-21.
- Kondziolka, D., Dempsey, P. K., Lunsford, L. D., Kestle, J. R., Dolan, E. J., Kanal, E., & Tasker, R. R. (1992). A comparison between magnetic resonance imaging and computed tomography for stereotactic coordinate determination. *Neurosurgery*, 30(3), 402-407.
- Kotecha, R., Gondi, V., Ahluwalia, M. S., Brastianos, P. K., & Mehta, M. P. (2018). Recent advances in managing brain metastasis. *F1000Research*, 7.
- Langen, K. J., Galldiks, N., Hattingen, E., & Shah, N. J. (2017). Advances in neuro-oncology imaging. *Nature Reviews Neurology*, 13(5), 279-289.

- Masucci, G. L. (2018). Hypofractionated radiation therapy for large brain metastases. *Frontiers in Oncology*, 8, 379.
- Moayeri, A., Niazi, H., & Darvishi, M. (2020). Effect of biocanin a in the acute phase of diffuse traumatic brain injury. *International Journal of Pharmaceutical and Phytopharmacological Research*, 10(1), 77-86.
- Mojahed, S., Shekari, M., Bokaie, M., & Dehghani, A. (2021). The effect of training in pregnant women on beliefs and intention to do FGM. *Journal of Advanced Pharmacy Education and Research*, 11(4), 136-142.
- Perkins, A., & Liu, G. (2016). Primary brain tumors in adults: Diagnosis and treatment. *American Family Physician*, 93(3), 211-217.
- Pope, W. B. (2018). Brain metastases: Neuroimaging. *Handbook of Clinical Neurology*, 149, 89-112.
- Pötter, R., Heil, B., Schneider, L., Lenzen, H., Al-Dandashi, C., & Schnepfer, E. (1992). Sagittal and coronal planes from MRI for treatment planning in tumors of brain, head and neck: MRI assisted simulation. *Radiotherapy and Oncology*, 23(2), 127-130.
- Purdy, R. A., & Kirby, S. (2004). Headaches and brain tumors. *Neurologic Clinics*, 22(1), 39-53.
- Putz, F., Mengling, V., Perrin, R., Masitho, S., Weissmann, T., Rösch, J., Bäuerle, T., Janka, R., Cavallaro, A., Uder, M., et al. (2020). Magnetic resonance imaging for brain stereotactic radiotherapy. *Strahlentherapie und Onkologie*, 196(5), 444-456.
- Snell, J. W., Sheehan, J., Stroila, M., & Steiner, L. (2006). Assessment of imaging studies used with radiosurgery: A volumetric algorithm and an estimation of its error. *Journal of Neurosurgery*, 104(1), 157-162.
- Stupp, R., Mason, W. P., Van Den Bent, M. J., Weller, M., Fisher, B., Taphoorn, M. J., Belanger, K., Brandes, A. A., Marosi, C., Bogdahn, U., et al. (2005). Radiotherapy plus concomitant and adjuvant temozolomide for glioblastoma. *New England Journal of Medicine*, 352(10), 987-996.
- Sumanaweera, T. S., Adler Jr, J. R., Napel, S., & Glover, G. H. (1994). Characterization of spatial distortion in magnetic resonance imaging and its implications for stereotactic surgery. *Neurosurgery*, 35(4), 696-704.