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Abstract

Spatial Patterns of Local Recurrence following Post-Operative Stereotactic Radiosurgery to Resected Brain Metastases: A Quantitative Analysis to Guide Target Delineation

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Abstract

Objectives: A recent prospective study questioned the efficacy of stereotactic radiosurgery (SRS) to the resection cavity after surgical resection of brain metastases. However, previous studies have not quantitatively evaluated the patterns of local treatment failure. In order to optimize target delineation, we present the first quantitative analysis evaluating the spatial characteristics of local recurrence following SRS to the resection cavity.

Methods: Patients with brain metastases treated with SRS to the cavity after resection between 2011 and 2016 were evaluated. Local failure in the tumor bed was defined by pathologic confirmation or progression on serial MRI scans leading to further radiotherapy to the same site. T1 post-gadolinium MRIs taken directly prior to initial surgery and at recurrence were co-registered to the SRS simulation CT, containing the originally contoured resection cavity (clinical target volume). Nodular enhancing tumor prior to the initial surgery and at recurrence was contoured. Percentages of overlap assessed the spatial relationships among pre-operative and recurrent tumor volumes and resection cavities. Overlap volume histograms (OVH) measured the proximity of tumor volumes and cavities to the meninges.

Results: 182 patients were included in the analysis. Median dose to the resection cavity was 21 Gy (range: 15–25 Gy) in a median of 3 fractions (range: 1–5). 18 patients experienced local treatment failure with 19 tumor bed recurrences in total. Local recurrence was not related to biologically effective dose (HR=1.0, CI=[0.8,1.3]), number of fractions (HR=1.0,CI=[0.7,1.4]), or radioresistant primary tumor (HR=0.9, CI=[0.3,2.6]). The resection cavity originally contoured as the SRS target volume overlapped with a median of 69.6% of the recurrent tumor volume. One target volume out of 19 did not overlap with the recurrent tumor volume at all. OVH

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analysis indicated that, while recurrent tumors and target volumes were in similar proximity to the meninges, both recurrent tumors and target volumes were closer to the meninges than pre-operative tumors (p=0.03). Although tumors recurred closer to the meninges, a median 10.8 mm expansion of the target volume from the meninges was required to increase overlap with the recurrent tumor volume to 95%. Including the entire pre-operative tumor extent in the target volume increased overlap with the recurrent tumor volume to a median of 76.8% but expanded the target volume to a median of 179.3% of its original size. Thus, expanding the target volume from the meninges and including the pre-operative tumor extent in the target volume do not efficiently increase overlap with the recurrent tumor volume. In contrast, increases in overlap with the recurrent tumor volume were achieved most efficiently by uniformly expanding the contoured cavity; median 2.8 mm and 4.2 mm expansions covered 90% and 95% of the recurrent tumor volume, respectively.

Conclusions: After SRS to the resection cavity, brain metastases recur closer to the meninges than at initial presentation. However, expanding the target volume from the meninges does not efficiently improve coverage of the recurrent tumor. Including the pre-operative tumor extent in the target volume also provides little benefit. In contrast, larger uniform expansions of the resection cavity efficiently increase coverage of the volume later occupied by recurrent tumor and may reduce local recurrence rates.