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Bridging surgery and radiotherapy: the role of stereotactic radiosurgery in pediatric brain tumor care

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Abstract

Background: Pediatric brain tumors (PBTs) are the most common solid malignancy in children. While surgery and fractionated radiotherapy remain cornerstones, stereotactic radiosurgery (SRS) is increasingly used for selected intracranial targets to maximize local control while limiting dose to surrounding normal tissue. However, evidence regarding efficacy and long-term toxicity in children remains uncertain.

Purpose: This systematic review examines the role of SRS in pediatric brain tumor care, focusing on tumor local control (LC), overall survival (OS), and the toxicity associated with SRS and highlighting practical considerations at the interface of surgery and radiotherapy.

Methods: A systematic search of PubMed, Scopus, EBSCO, Wiley, and Web of Science was conducted using terms related to "SRS" and "pediatric brain tumors." Studies reporting outcomes in patients ≤ 18 years were included; when mixed pediatric/young adult cohorts were reported, pediatric-specific outcomes were extracted when available. Findings were synthesized narratively because of heterogeneity in study design, dose prescription, and outcome reporting.

Results: Seventeen studies (1996-2022) encompassing 358 pediatric patients were included. The median age was 11 years, with a male predominance (63%). The most common tumor histologies were pilocytic astrocytoma, craniopharyngioma, ependymoma, and medulloblastoma. Single-session SRS marginal doses were typically 11-16 Gy, while hypofractionated SRS regimens delivered 24-42 Gy in 3-5 sessions. One-year OS ranged from 85 to 100%. LC rates ranged from 29 to 100%, varying by histology and treatment setting (e.g., salvage vs. adjuvant). Reported toxicities included transient edema, pseudoprogression, radiation necrosis, and optic neuropathy, most often in heavily pre-treated patients and/or lesions near critical structures.

Conclusions: Current evidence suggests that SRS can be a feasible, generally well-tolerated option for carefully selected pediatric brain tumors, particularly small-volume, deep-seated, residual, or recurrent lesions. Nevertheless, the certainty of evidence is low because most data arise from nonrandomized retrospective series with heterogeneous outcome definitions and limited long-term follow-up. Multidisciplinary patient selection, optimized dose planning with strict organ-at-risk constraints, and long-term survivorship monitoring remain essential. Prospective, multicenter studies with standardized reporting are needed to better define tumor-specific dose-response relationships and

late toxicity.

Keywords: Local control; Pediatric brain tumors; Stereotactic radiosurgery; Systematic review; Toxicity.