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The Role of Frameless HyperArc Radiosurgery Program in a Historic Gamma Knife Center

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Abstract
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Abstract

Objectives:

Our institution is known to be a historical Gamma Knife (GK) stereotactic radiosurgery (SRS) center, having the 6th Leksell GK unit in the nation installed in the early 1990s (currently, using PerfexionTM unit). Recently, to supplement this program, our institution installed and commissioned the fully-automated HyperArc SRS (HA-SRS) program (in January 2021) with Qfix mask and Encompass support patient immobilization device. Our first HA-SRS patient who presented with large intracranial tumor bed was treated in March 2021. Due to fundamental differences in treatment delivery workflow, we have found that the frameless HA-SRS can be complementary to the frame-based GK-SRS system for select patients and disease types. Especially for large, intracranial tumors or resection cavities, allowing for fractionated SRS more so for lesions abutting adjacent critical organs such as the optic pathway, brainstem, or spinal cord. Herein, we present the effect of adding a new HyperArc program to an existing, and successful, GK-SRS practice as well as a brief analysis on the patient selections criteria for the two radiosurgery platforms.

Methods:

Frame-based GK offers highly-precise, same-day SRS treatment. However, significant clinical challenges arise with this method including: patient tolerability to relatively longer treatment times, suboptimal prescription dose from tumor progression on treatment day, headframe fixation difficulties due to large and/or double craniotomy sites, challenges coordinating with anesthesia team for claustrophobic patients or who may not tolerate headframe fixation, and tighter federal and state radiation safety and regulatory concerns. For a select patient cohort, we are able to avoid these issues using HA-SRS, started in March 2021. We have credentialled Alliance A071801 brain SRS/SRT trial for patient requirement on both GK and HA-SRS platforms via IROC MD Anderson's SRS head phantom(s) irradiation. For HA-SRS, target volume was gross tumor volume plus 1-2 mm margin via contrast-enhanced MPRAGE-MRI co-registered with the high-resolution (1 mm cuts) planning CT images. As per Alliance brain SRS/SRT trial, therapeutic prescription doses of 18 to 21 Gy in 1 fraction (tumor size, 2-3 cm), 27 Gy in 3 fractions (3-4 cm), and 30 Gy in 5 fractions (larger tumor beds up to 7 cm) prescribed to 70-80% isodose lines (with greater than 95% of each target volume receiving 100% of dose) were delivered on a TrueBeam Linac (6MV-FFF beam) via conebeam CT-guidance with PerfectPitch 6-DoF couch corrections. Radiosurgery indications for the past 2 years via HA-SRS was presented.

Results:

All SRS patients who present with arteriovenous malformations, pituitary adenomas, acoustic schwannoma/neuroma and functional diseases (trigeminal neuralgia, Parkinson's disease and essential tremors) were treated with frame-based GK-SRS. Metastatic brain lesions that could pose concern of small-field dosimetry errors on Linac-based treatment were also treated with GK-SRS. Typically, about 150 patients per year are treated on our GK PerfexionTM unit (~300 patients in the past 2 years). However, in the past 2 years, 129 patients who were not suitable for GK-SRS (for different reasons as mentioned above) were treated for single or multiple brain metastases (up to 13 lesions) via highly-conformal, single-isocenter/multi-lesion HA-SRS plan; otherwise these patients may receive suboptimal 3D-conformal or whole brain RT. Dose tolerances to critical organs were respected following various fractionation schemes per QUANTEC and Alliance trial's criteria. Patient set up errors on pre-treatment conebeam CT imaging were within the departmental SRS/SRT protocol requirements (within ±1mm/1o). For large brain tumors, fractionated HA-SRS (3-5 fractions) was delivered every other day. All patients tolerated HyperArc Qfix mask with mouth-bite piece and had an overall treatment time < 15 minutes per treatment. Additionally, to avoid patient

collision issue and provide the optimal target coverage on GK-SRS, the HA-SRS was commissioned for a single-high dose of 18 Gy to glomus jugulare tumors (GJT) and locally recurrent, previously irradiated head and neck cancers for 30-40 Gy in 5 fractions, every other day. In the past 2 years, we have already treated 39 previously irradiated recurrent PET-avid head and neck cancers SRT patients via fully-automated HA-SRT plans.

Conclusion(s):

Albeit the majority of our patients were treated with frame-based GK-SRS, a significant proportion were selected for HA-SRS, expanding the capabilities of our historic GK-SRS program (only GK unit in our state)–GK-SRS cases did not go down. The HA-SRS patient group included patients who would benefit from fractionated SRS to single and multiple brain lesions, or those who may not tolerate or want the frame-based GK-SRS. Currently ongoing at our institution is the treatment of complex and difficult recurrent head and neck SRT patients with highly compact and steep dose gradient to spare their critical organs via HA-SRT with no patient collision concern. Clinical follow-up results of tumor local control rates and toxicity profiles for patients in both cohorts of intracranial metastatic lesions and extracranial recurrent head and neck cancers via HA-SRS/SRT is warranted. We recommend Linac-based SRS users to commission and implement HyperArc module for their patients.