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# Reporting Clinical Results of EPID-Based Patient-Specific Quality Assurance for Brain SRS/SRT: Demonstrating the Feasibility of Same Day Stereotactic Radiosurgery via HyperArc Delivery

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**Abstract**
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Damodar Pokhrel [1], Joshua Misa [2], Shane McCarthy [3], William St Clair [4]

1. Physics, University of Kentucky, Lexington, USA 2. Department of Radiation Oncology, University of Kentucky, Lexington, USA 3. Department of Radiation Medicine, University of Kentucky, Lexington, USA 4. Radiation Medicine, University of Kentucky, Lexington, USA

**Corresponding author:** Damodar Pokhrel, damodar.pokhrel@uky.edu

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## Abstract

Objectives:

Unlike the same day stereotactic Gamma Knife radiosurgery procedure, the current LINAC-based treatment workflow from the patient's CT simulation to their first treatment can range from 1 to 2 weeks. This is due to the highly involved treatment planning process and lack of automation in the treatment plan generation such as manual contouring of critical organs, manual planning, and traditional labor and time intensive patient-specific quality assurance (PSQA) methods which hinders the feasibility of same day radiosurgery treatment for LINAC-based delivery – significantly prolonging patient's CT simulation-to-treatment start date/time. In our clinical experience, this workflow is severely inconvenient for brain SRS/SRT patients and chances of tumor(s) recurrence. These patients may not have the most recent MRI scans for tumor(s) delineation at the time of CT simulation, that will also delay the treatment start date. In our extensive clinical experience and reported by other researchers, longer simulation-to-treatment time was detrimental to patient care with brain lesion(s) due to rapid tumor growth during that time and tumor spatial displacement due to edema. Recently, for complex volumetric modulated arc therapy (VMAT) plans, the rapid EPID-based portal dosimetry (PD) QA is widely adopted by the radiation therapy community. Thus, to speed up the brain SRS/SRT treatment process, in our clinic we have commissioned and implemented the EPID-based PD method. Herein we report our EPID-based PSQA clinical results for brain HyperArc SRS/SRT patients, justifying its efficiency for the potential of same-day LINAC-based radiosurgery.

Methods:

A total of 130 brain SRS/SRT patients were treated via manually generated highly conformal HyperArc plans for 1, 3, and 5 fractions of 18–24 Gy, 24–27 Gy, and 30–35 Gy to each lesion in either single-isocenter/single-lesion (SISL, 60 plans) or single-isocenter/multi-lesion (SIML, 70 plans) setting following the Alliance brain SRS/SRT trial criteria. For the SIML brain SRS/SRT plans, the average distance-to-isocenter and number of treated lesions were 4.61 ±1.32 (range, 1.22–6.80) cm and 4.0 ± 3.0 (range, 2.0–15.0), respectively. Acuros-based dose engine for 6MV-FFF beam (maximum dose rate, 1400MU/min) was used. For each HyperArc SRS/SRT plan, EPID-based PD PSQA was performed. Independent 3D dose verification of these brain SRS/SRT plans was done via an in-house Monte Carlo (MC) program that was based on PENELOPE code, within 3% statistical uncertainty for a 2 mm dose calculation grid size. The PSQA results, total QA time including ARIA documentation, MC agreement with AcurosXB algorithm, and MLC modulation (MF) were analyzed.

Results:

The average gamma passing rates were 99.4 ± 0.9 (range, 95.4–100.0) % for SISL and 96.9 ± 1.7 (range, 95.1–100.0) % for SIML plans with a tighter 2%/2mm clinical gamma criteria ($p < 0.01$). Compared to SISL plans, SIML plans had a higher average MF by a factor of 1.2, maximum up to 1.4 ($p < 0.001$), on average 3.25 ± 0.73 (range, 1.89–5.30) vs 3.99 ± 1.25 (range, 2.09 – 7.15). We also observed a slight correlation between MF and the number of treated lesions. Although SIML plans had relatively lower PSQA pass rates compared to SISL, all plans met the clinical QA criteria for HyperArc delivery. The SIML vs SIML overall PSQA times were 10.27 ± 1.16 (range, 8.94–15.34) minutes vs 10.65 ± 1.14 (range, 9.17–15.25) minutes with statistically insignificant, $p = 0.129$. Both SISL and SIML EPID-based PSQA plans were completed in within 16 minutes. Moreover, independent second physics check via in-house 3D-MC dose verification for both SISL, -1.6 ±2.0 (range, -4.6–4.2) % and SIML, -0.1 ± 2.1 (range, -3.9–4.5) % respectively, overall results were within ±5% agreement compared to advanced AcurosXB calculation. The MC-based second check was completed within

15 minutes including ARIA documentation.

Conclusion(s):

These promising PSQA results for complex clinical HyperArc brain SRS/SRT plans (both SISL and SIML) delivered in a timely manner via EPID-based PD and independent MC second check demonstrates EPID-based PD is a fast, safe, and efficient patient-specific quality assurance method for HyperArc SRS/SRT treatments of single- and multiple brain lesions. With proper automation of contouring tool and SRS planning via RapidPlan model, this EPID-based PSQA method can be safely adapted for same day HyperArc delivery of high-quality brain SRS/SRT treatments in the future. That will expand the access of high-quality cancer care to underserved patient population including the patients in community practices via LINAC-based HyperArc delivery method to them who do not have access to advanced system such as Gamma Knife radiosurgery.