Gyroscopic Radiosurgery for Brain Metastases

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Objectives: ZAP-X is the newest cranial stereotactic radiosurgery (SRS) platform. There are few reports describing its use or outcomes for brain metastases (BM). In this study, dosimetric parameters, initial clinical outcomes, and a novel approach for mixed fractionation schemes are presented for ZAP-X BM SRS.

Methods: 170 patients (399 targets) were treated with ZAP-X BM SRS. Average prescription dose was 23 ± 4 Gy (range: 18 – 30 Gy), average number of targets was 3 ± 2 (1 – 10), average target volume was 5 ± 8 cc (0.05 – 29.29 cc), average conformity index was 1.3 ± 0.3 (0.707 – 3.872), average gradient index was 3.5 ± 0.8 (2.131 – 6.403), and average V1200cGy was 20 ± 30 cc (0.217 – 151.911 cc). Primary tumors included pulmonary (54.2%), skin (10.3%), gastrointestinal (9.4%), renal (9.3%), breast (8.4%), head and neck (2.8%), genitourinary (2.8%), liver (1.9%), and blood (0.9%). Follow-up was scheduled at 1-month post-treatment then 3-month intervals. Complete response was defined as no visible target lesion, partial response ≥ 30% decrease in longest diameter, stable < 30% decrease in longest diameter, progressive disease ≥ 20% or 2.5 mm increase in longest diameter. Cystic and surgical cavity tumors were excluded from response assessment. To accommodate mix fractionation schemes for ZAP-X BM SRS, targets are first optimized in one single plan (Plan_A) using a single fractionation to their prescribed doses. After optimization, isocenters with new beams/MUs on them are split into groups with their associated targets to make individual plans (Plan_A_PTV1, Plan_A_PTV2, etc.) with proper fractionation. Each plan is then only re-prescribed to any isodose level to scale the dose to achieve 99% coverage on respective targets. After individual plans achieve 99% dose coverage, plan sum for individual plans are compared on clinical objectives using Timmerman dose constraints.

Results: For 65 patients consisting of 264 targets, median follow-up was 8 months (IQR: 4 – 13 months), 135 targets (51.1%) were classified as complete response, 97 (36.7%) as partial response, 20 (7.6%) as stable, and 2 (0.8%) as progressive disease. The 2-year Kaplan-Meir local tumor control was 98%. 1 patient (1.5%) developed radiation necrosis. The plan-and-split approach produces quality plans meeting clinical objectives with only one optimization, saving tremendous time in treatment planning for multi-fractionation ZAP-X BM SRS.

Conclusion(s): ZAP-X platform demonstrates promising initial outcomes, with favorable dosimetric performance and local control rates, reinforcing its potential as a standard tool in SRS for BM.