

# CyberKnife Radiosurgery for brain metastases

A study of Takizawa et al. aimed to evaluate the effect of target positioning error (TPE) on radiobiological parameters, such as tumor control probability (TCP) and normal tissue complication probability (NTCP), in [stereotactic radiosurgery](#) (SRS) for [brain metastases](#) of different sizes using [CyberKnife](#). The reference SRS plans were created using the circular cone of the CyberKnife for each spherical gross tumor volume (GTV) with diameters ( $\phi$ ) of 5, 7.5, 10, 15, and 20 mm, contoured on computed tomography images of the head phantom. Subsequently, plans involving TPE were created by shifting the beam center by 0.1-2.0 mm in three dimensions relative to the reference plans using the same beam arrangements. Conformity index (CI), generalized equivalent uniform dose (gEUD)-based TCP, and NTCP of estimated brain necrosis were evaluated for each plan. When the gEUD parameter "a" was set to -10, the CI and TCP for the reference plane at the  $\phi$ 5-mm GTV were 0.90 and 80.8%, respectively. The corresponding values for plans involving TPE of 0.5-mm, 1.0-mm, and 2.0-mm were 0.62 and 77.4%, 0.40 and 62.9%, and 0.12 and 7.2%, respectively. In contrast, the NTCP for all GTVs was the same. The TCP for the plans involving a TPE of 2-mm was 7.2% and 68.8% at the  $\phi$ 5-mm and  $\phi$ 20-mm GTV, respectively. The TPEs corresponding to a TCP reduction rate of 3% at the  $\phi$ 5-mm and  $\phi$ 20-mm GTV were 0.41 and 0.99 mm, respectively. TPE had a significant effect on TCP in SRS for metastatic brain tumors using CyberKnife, particularly for small GTVs <sup>1)</sup>.

The introduction of hypofractionated [stereotactic radiosurgery](#) (hSRS) extended the treatment modalities beyond the well-established single-fraction stereotactic radiosurgery and fractionated radiotherapy. Here, we report the efficacy and side effects of hSRS using Cyberknife® (CK-hSRS) for the treatment of patients with critical brain metastases (BM) and a very poor prognosis. We discuss our experience in light of current literature.

**Methods:** All patients who underwent CK-hSRS over 3 years were retrospectively included. We applied a surface dose of 27 Gy in 3 fractions. Rates of local control (LC), systemic progression-free survival (PFS), and overall survival (OS) were estimated using Kaplan-Meier method. Treatment-related complications were rated using the Common Terminology Criteria for Adverse Events (CTCAE).

**Results:** We analyzed 34 patients with 75 BM. 53% of the patients had a large tumor, tumor location was eloquent in 32%, and deep seated in 15%. 36% of tumors were recurrent after previous irradiation. The median Karnofsky Performance Status was 65%. The actuarial rates of LC at 3, 6, and 12 months were 98%, 98%, and 78.6%, respectively. Three, 6, and 12 months PFS was 38%, 32%, and 15%, and OS was 65%, 47%, and 28%, respectively. Median OS was significantly associated with higher KPS, which was the only significant factor for survival. Complications CTCAE grade 1-3 were observed in 12%.

**Conclusion:** Our radiation schedule showed a reasonable treatment effectiveness and tolerance. Representing an optimal salvage treatment for critical BM in patients with a very poor prognosis and clinical performance state, CK-hSRS may close the gap between surgery, stereotactic radiosurgery, conventional radiotherapy, and palliative care <sup>2)</sup>.

<sup>1)</sup>

Takizawa T, Tanabe S, Nakano H, Utsunomiya S, Sakai M, Maruyama K, Takeuchi S, Nakano T, Ohta A, Kaidu M, Ishikawa H, Onda K. The impact of target positioning error and tumor size on radiobiological

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2)

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Last update: **2025/05/13 02:25**

