

Clinical Outcomes Following LINAC Radiosurgery for Trigeminal Neuralgia as a Function of Calculated Biologically Equivalent Dose

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Purpose

The present study aims to evaluate the clinical outcomes of single-fraction LINAC-based stereotactic radiosurgery (SRS) for trigeminal neuralgia (TN), including pain relief and facial numbness, correlate these outcomes with the biologically effective dose (BED), and determine whether BED-based predictions derived from Gamma Knife treatments are also applicable to LINAC radiosurgery, despite the differences in terms of a smaller continuous dose rate in GK vs higher pulsed dose rate in LINACs.

Materials and Methods

A total of 8 patients with TN were treated with SRS between 2021 and 2026. MRI images in T1 MPRAGE and T2 CISS, along with planning CT, were acquired. Images were imported into Brainlab Elements, for image registration, geometrical distortion correction and target definition. Dose distributions were calculated with Siemens Healthineers Eclipse. Treatments were delivered on a Siemens Healthineers TrueBeam system using a 4 mm diameter circular cone with 6-10 MV flattening filter-free (FFF) photon beams in 9 partial arcs. A prescribed physical dose of 85–90 Gy was delivered to the target, centered in Trigeminal Nerve, approximately 7 mm anterior to the Dorsal Entry Zone (DREZ). Patients were immobilized with thermoplastic open face masks, and positioned using cone-beam computed tomography (CBCT) prior to treatment. Continuous surface-guided radiation therapy (SGRT) was used for intrafraction motion monitoring with a threshold of 1 mm and 1°, and additional intrafraction CBCT were performed. Total treatment time and total beam-on time were recorded. BED was calculated in two methods: Tuleasca et al. and Jones & Hopewell A9 equation both with α/β ratio of 2.47 Gy. Patients were submitted to a follow-up questionnaire regarding facial numbness, pain, medication and procedures.

Results

Prescribed physical dose, total treatment time, beam-on time, calculated BEDs and difference between methodologies are shown in Table 1.

Patient	Physical Dose (Gy)	TIME (min)		BED (Gy 2,47)		Delta
		Total treatment	Beam-on	Tuleasca et. Al	Jones&Hopwell	
1	90	52,2	10,8	2283	2382	4%
2	90	32,8	10,7	2574	2616	2%
3	85	35,7	10,5	2259	2302	2%
4	85	33,4	10,1	2291	2331	2%
5	90	31,8	10,8	2590	2631	2%
6	90	76,1	11,0	1973	2182	10%
7	90	32,2	11,0	2582	2623	2%
8	90	42,2	18,1	2429	2472	2%
		Mean ± STD (min)		Mean ± STD (Gy 2,47)		
		Total treatment	Beam-on	Tuleasca et. Al	Jones&Hopwell	
		42,0 ± 15,4	11,6 ± 2,6	2373 ± 215	2442 ± 170	

Table 1. Treatments data and calculated parameters.

The mean follow-up was 29 months, 100% of patients reported reduced or no pain at the follow-up, 75% of them reported not to be in or a reduction in medication and 87,5% affirmed that would undergo another SRS if necessary. Four patients reported facial numbness of any grade; however, two had pre-SRS facial numbness. Therefore, new post-SRS facial numbness occurred in 25% of patients, with both reporting "no impact on daily life" in the questionnaire.

Conclusion

BED calculations using both methods showed good agreement, with reduced concordance when total and beam-on times were more discrepant. As shown by Tuleasca et al., treatments with a BED ≥ 1820 Gy achieved 95% efficacy, in line with our cohort. The same study reported an approximately 20% risk of facial numbness at a BED of 2390 Gy. Since this value falls within the range of our calculated mean BED values, the observed 25% incidence of side effects corroborates these findings. Finally, although our results support the applicability of Gamma Knife-derived BED models to LINAC-based radiosurgery, further investigation in larger patient cohorts is required to confirm these findings.

References: Tuleasca et al. World Neurosurg. 2020;134:e204-e213. Jones & Hopewell. Br J Radiol. 2019;92:20180111.