Optimizing conformity and normal tissue sparing in multi-met SRS: A LINAC-Gamma Knife dosimetric comparison

Cristina Teixeira[1], Orbay Askeroğlu[2], Marlies Boussaer[1], Sven Van Laere[1], Mark De Ridder[1], Selçuk Peker[2] and Thierry Gevaert[1]

1) UZ Brussel, Vrije Universiteit Brussel, Radiotherapy, Brussels, Belgium
2) Koç University Hospital, Department of Neurosurgery, Gamma Knife Center, Istanbul, Turkey

ISRS 2026 SYDNEY, AUSTRALIA 31ST MAY - 3RD JUNE

Purpose

Linac-based single-isocenter (SIT) stereotactic radiosurgery (SRS) enables efficient treatment of multiple brain metastases but may compromise conformity and low-dose spillage. Dual-isocenter technique (DIT) may overcome these limitations, while Gamma Knife (GK) remains the benchmark for SRS. This study compares SIT and DIT against GK, with particular attention to conformity and low-dose brain exposure.

Results:

GK achieved the highest PCI (0.82±0.15), followed by nonsignificant difference for DIT approach (0.74±0.13), while SIT showed significant lower conformity (0.70±0.12). Conformity with GK increased with lesion volume, whereas no clear volume dependence was observed for the linac- based techniques. GK consistently produced the lowest low-dose volumes. DIT planning reduced low-dose spread compared with SIT delivery, with the relative benefit increasing at lower dose levels (approximately 6% reduction at V12, rising to 17% at V3). Across techniques, low-dose volumes rose with total tumor burden, while very-low-dose exposure was additionally driven by lesion count with SIT.

Figure 1 shows a typical dose distribution of Gamma Knife, SIT, and DIT. Figure 2 shows an automated single isocenter arc arrangement with island blocking (A) and a dual-isocenter (B1–B2) arc arrangement and isocenter placement for a patient with 10 brain lesions.

Material and Methods:

Fourteen patients with 4–10 brain metastases (81 lesions) were planned using GK and Brainlab Elements Multiple Brain Mets v4.0 using automated geometric optimization for SIT and DIT linac plans. Lesions were spatially clustered for DIT, assigning one isocenter per cluster. Plan quality was assessed using Paddick Conformity Index (PCI) per lesion and low-dose brain volumes 12Gy (V12), 10Gy (V10), 5Gy (V5), 4Gy (V4), and 3Gy (V3) per patient. Technique differences were tested using Friedman repeated-measures tests with Holm-adjusted paired Wilcoxon comparisons.

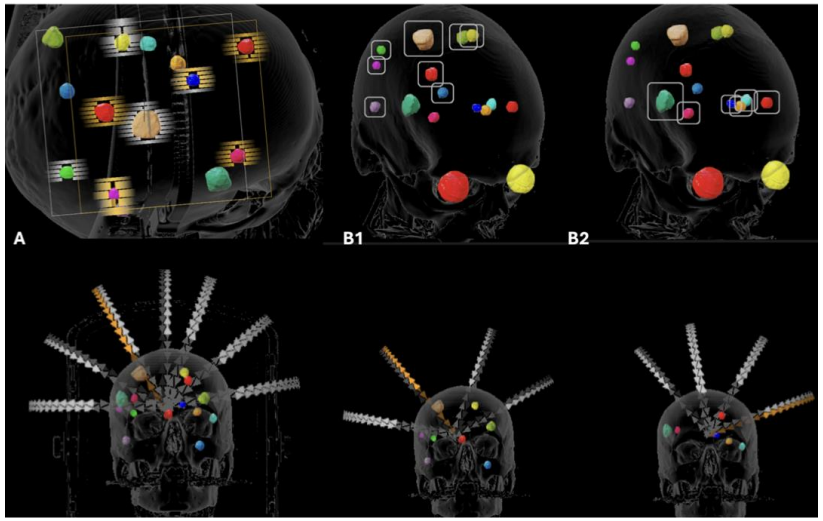

Figure 2. Patient with 10 lesions. (A). Single-isocenter technique with island blocking. (B1). Dual-isocenter 1st arc arrangement and isocenter placement and (B2). Dual-isocenter 2nd arc arrangement and isocenter placement.

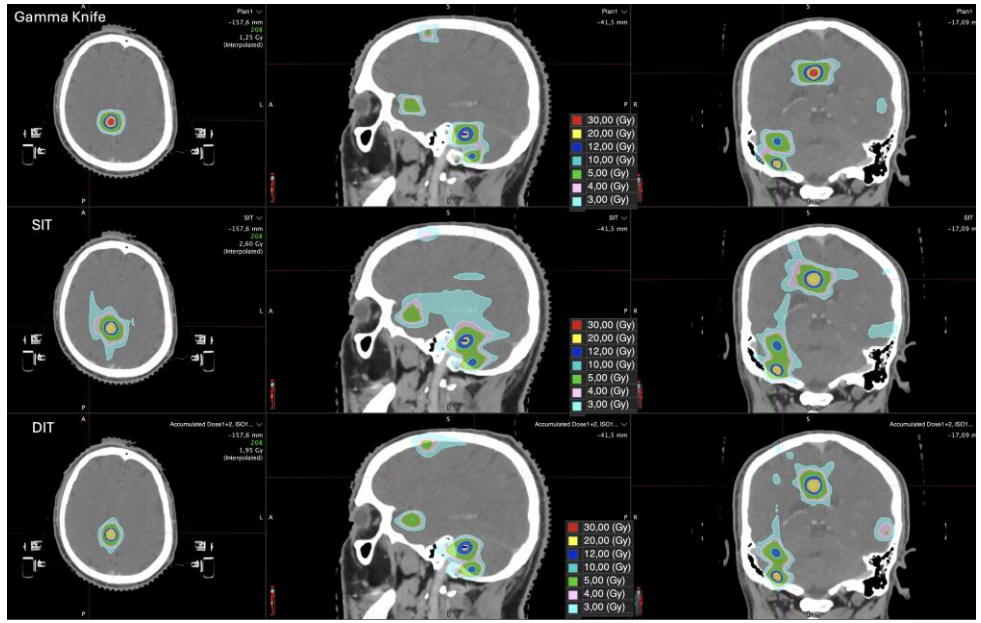

Figure 1. Typical dose distribution Gamma Knife, single-isocenter technique (SIT) and dual-isocenter technique (DIT) for a patient with 6 brain metastases. Identical dose color scales and isodose levels are used across the three techniques.

Conclusions:

DIT offers clear dosimetric benefits over SIT, with better target conformity and reduced low-dose spread. Compared with DIT, GK shows no major PCI advantage overall, though its benefit increases with lesion size and it remains superior for very-low-dose sparing. Overall, DIT is a clinically relevant balance between plan quality and efficiency, narrowing the gap with GK for suitably clustered metastases.