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Introduction

- Leksell Gamma Knife Icon™ enables frameless radiosurgery using a thermoplastic mask, cone-beam CT, and high-definition motion management (HDMM).
- Frameless fixation improves patient comfort compared with conventional frame-based treatment, but intra-fraction motion remains a major concern.
- The HDMM system monitors motion using a reflective nose marker, yet it provides only overall 3D radial displacement.
- As a result, motion along the individual X, Y, and Z axes cannot be directly identified during treatment.
- This study investigated axis-specific coordinate changes of the nose marker during frameless Gamma Knife radiosurgery in patients with meningioma and metastases.

Materials and Methods

- We retrospectively reviewed 60 patients with meningioma (n=30) or metastases (n=30) who underwent frameless Gamma Knife radiosurgery using the Leksell Gamma Knife Icon™ between January and September 2023. (Table 1)
- All patients were immobilized with a head cushion and a Nanor thermoplastic mask using the plain fixation method.
- Coordinate-defining CBCT (CTDIw 6.3 mGy) and setup CBCT (CTDIw 2.5 mGy) were obtained before treatment, and planning was performed with Leksell Gamma Plan Sequential HDMM nose-marker log data were extracted and classified into X, Y, and Z coordinates, and artifacts were removed during preprocessing.
- Average intra-fraction motion was analyzed by axis and over time at 30-minute intervals up to 90 minutes using one-way ANOVA with Tukey post-hoc testing.

Results

Table 1. Demographics of patients with meningioma or metastases

Characteristic	Meningioma	Metastases
Number of patients	30	30
Median age (years)	64.5	68.5
Sex		
Male	14	13
Female	16	17
Mask fixation methods	Plain type	Plain type
KPS score		
100	20	18
90	10	12
Primary cancer		
Lung cancer	-	19
Breast cancer	-	7
Others	-	4
Median beam-on time (minutes)	44.2	93.75
Prescription dose (50% isodose line)		
Single-fractionated	13Gy	19-25 Gy
Hypo-fractionated	-	5 Gy×5 fraction or 7×3 fraction (within 24-72 hours interval)
The tumor volume (cm ³)	1.59	8.449

KPS: Karnofsky performance scale

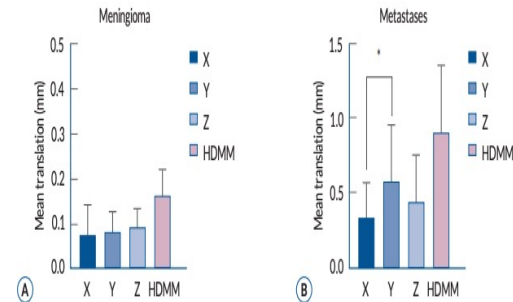


Fig. 1. Intra-fraction motion in meningioma and metastases patients. No significant differences were observed in the X, Y, and Z axes in meningioma patients (A). In metastases patients, Y axis translation was significantly increased (*indicating a statistically significant difference compared to the X axis. (B) One-way analysis of variance (ANOVA) test with post-hoc Tukey test.

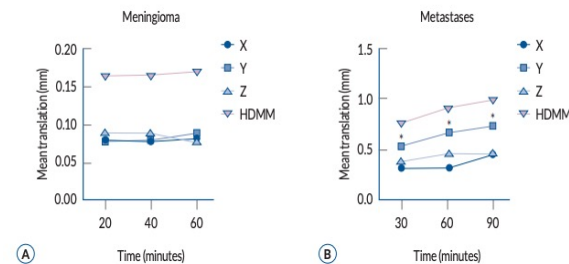


Fig 2. Intra-fraction motion over treatment time in meningioma and metastases patients. No significant intra-fractional differences were observed in the X, Y, and Z axes in meningioma patients (A). In metastases patients, differences in the X, Y, and Z axes emerged 30 minutes after the start of treatment, with * indicating a significant increase in Y-axis displacement after 30 minutes (p<0.05) (B). One-way analysis of variance (ANOVA) test with post-hoc Tukey test. HDMM : high-definition motion management.

Conclusion

- Frameless GKRS using the LGK Icon™ demonstrated overall stable patient fixation during treatment.
- Patients with meningioma showed minimal intra-fractional motion across the X, Y, and Z axes.
- Patients with metastases exhibited greater motion, particularly along the Y axis, after 30 minutes of treatment.
- Careful mask fixation, forehead support, and patient comfort are important to reduce motion during prolonged treatment.
- Patient-specific motion monitoring and appropriate fixation strategies are essential for optimizing treatment accuracy in frameless GKRS.

Publication Information

- This study has been published in the *Journal of Korean Neurosurgical Society*.
- Please contact us by email for any questions or further information. (jimmoon0602@daum.net)