



## Quantification of Intra-Fraction Motion by Immobilization Setup in Spine Stereotactic Body Radiotherapy (SBRT)

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**Objectives:** To quantify intra-fraction motion during spine SBRT delivered with two-arc Volumetric Modulated Arc Therapy (VMAT), and to evaluate the impact of accessory combinations on motion control for thoracic–sacral treatments.

**Methods:** A retrospective review spine SBRT delivered using two VMAT arcs per fraction on a Varian platform was performed. Cone-beam CT (CBCT) scans were acquired pre- and post-arc, and automated image registration was used to assess intra-fraction motion. Translational and rotational deviations exceeding  $1\text{ mm}/1^\circ$  and  $2\text{ mm}/2^\circ$  were recorded. Two immobilization systems were employed: (1) a head-and-shoulder thermoplastic mask with customized moldcare support for cervical to upper thoracic lesions (C1–T4), and (2) a body-positioning platform for thoracic to sacral sites (T5–S5). Within the body-positioning group, various accessory combinations that included arm bridges, compression belts, and pelvic supports were evaluated to identify configurations that provided optimal stability.

**Results:** A total of 344 arcs were evaluated, including 52 delivered to patients immobilized with a thermoplastic mask. Among these cases, 28.8% of arcs exceeded  $1\text{ mm}/1^\circ$  and 3.8% exceeded  $2\text{ mm}/2^\circ$ . For treatments using the body-positioning platform, motion varied by accessory combination. The most common setup (arm positioner + vacuum cushion + bridges) showed 13.2% of arcs exceeding  $1\text{ mm}/1^\circ$  and 1.8% exceeding  $2\text{ mm}/2^\circ$ . Setup configurations incorporating compression belts demonstrated improved stability, with fewer than 6% of arcs exceeding  $1\text{ mm}/1^\circ$  and none exceeding  $2\text{ mm}/2^\circ$ . Overall, motion across body-positioning setups ranged from 0–20% of arcs exceeding  $1\text{ mm}/1^\circ$ , depending on accessory combination and target location.

**Conclusion(s):** Spine SBRT delivered with modern image guidance demonstrates excellent intra-fraction stability, with translational and rotational deviations rarely exceeding  $2\text{ mm}/2^\circ$ . The frequency of motion exceeding  $1\text{ mm}/1^\circ$  varied by anatomical region and immobilization approach. Cervical and upper thoracic treatments immobilized with thermoplastic masks exhibited greater motion, while thoracic–sacral treatments using body-positioning systems showed high stability—particularly when compression belts were employed. These findings highlight the importance of tailoring immobilization strategies to the spinal level and accessory configuration, supporting continued refinement of motion management approaches for spine SBRT and informing planning target volume margin selection.

