Geometric evaluation of intrafraction motion during frameless intracranial stereotactic radiosurgery (SRS)

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Purpose

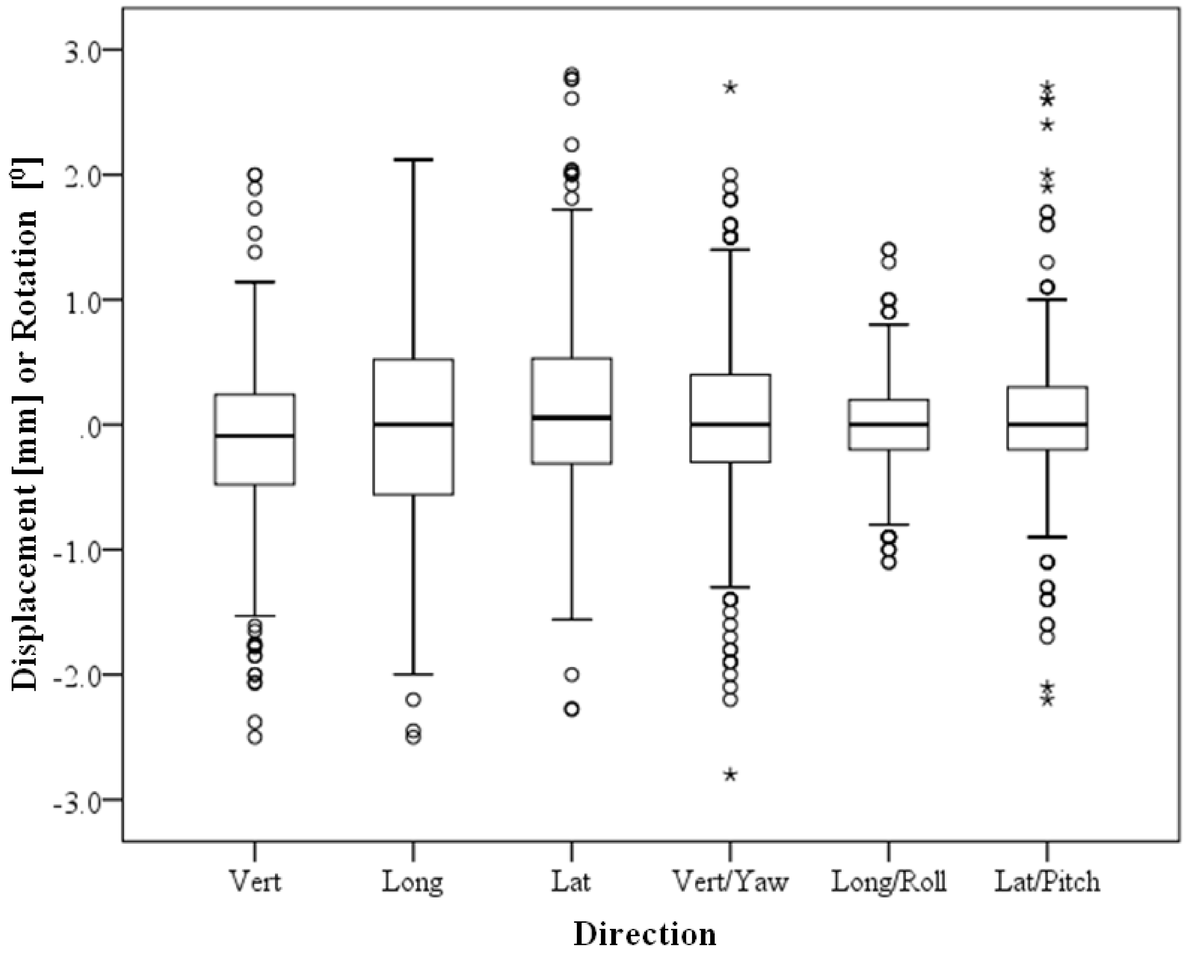
To quantify intrafraction motion during frameless intracranial stereotactic radiosurgery (SRS) using the six-degree-of-freedom (6DOF) stereoscopic x-ray imaging system.

Methods

Patient immobilization was accomplished by either a custom-fitted three-piece bivalve-style thermoplastic mask (BrainLAB AG, Heimstetten, Germany) or a three-point fixation Orfit mask system (Orfit Industries, Wijnegem, Belgium). Frameless positioning was based on online 6DOF stereoscopic x-ray (ExacTrac) imaging followed by online volumetric image guidance (CBCT) for residual error assessment. At least one mid-treatment ExacTrac acquisition was performed for motion assessment. The difference between the patient's position at the start and ate time of re-assessment was determined and labeled intrafraction motion.

Results

A cohort of 180 sequential patients that were subjected to frameless cranial SRS formed the basis of the current analysis. In total, 350 intrafraction ExacTrac image sets were evaluated (mode 1; range 1-3). Intrafraction translational motion was -0.1 mm (SD=0.7; range: -2.5–2.0), 0.0 mm (SD=0.8; range: -2.5–2.1), and 0.1 mm (SD=0.8; range: -2.3–2.8), in the vertical, longitudinal and lateral directions, respectively. The 3D vector was 1.1 mm (SD=0.7; range: 0.0–3.5). Intrafraction rotational alignment errors was 0.0 degrees (SD=0.8; range: -2.8–2.7), 0.0 degrees (SD=0.4; range: -1.1, 1.4), and 0.1 degrees (SD=0.7; range: -2.2–2.7) in the yaw, roll and pitch directions, respectively. Frequency of absolute motion in any direction >1 mm, >1.5 mm and >2 in any direction was 33%, 15% and 5% respectively. Frequency of 3D vector motion >1 mm, >1.5 mm and >2 was 48%, 25% and 10% respectively.



Conclusions

Intrafraction motion during frameless SRS delivery is typically small, albeit non-negligible. While motion along one or more room axes and 3D motion vectors >2 mm were observed no more than 10% of times, this finding may provide a rationale for development of planning target volume margins. Frequent intra-treatment positioning assessment can significantly contribute to the precision of frameless intracranial SRS.