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Influence of two-level quality assurance methodology on safety margins size and planning target volumes in frameless mask-based image-guided stereotactic intracranial radiosurgery and radiotherapy.

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Purpose

To estimate influence of adding tolerance levels (TL) to ultimate action levels (AL) in quality control (QC) of equipment geometrical precision in stereotactic radiotherapy on size of safety margins (SMs) and, consequently, planning target volumes (PTVs) in frameless image-guided stereotactic intracranial radiosurgery and radiotherapy (SRS/SRT) delivered with the Accuray CyberKnife 6D skull tracking and fixed aperture conical collimators (6DST).

Methods

AL and TL for SRS/SRT QC are employed in our institution. If errors fall between TL and AL one can operate till end of the day and then adjust. AL are set according to SSRMP recommendations No.18 tolerance levels (R.18.TL). Additionally, tighter TL are used, based on institution data and other recommendations. For End-to-End phantom-tests (E2E) AL is 1.00 mm 3D radial error and TL is 0.75 mm deviation in any direction. SMs were estimated using van Herk's recipe. Institution (E2E, intrafraction, σ_p) and literature (MRI-CT registration, GTV delineation) data was used. Prescription isodoses range was 70-80%. E2E errors distribution for R.18.TL was estimated by corresponding expansion of institution data.

Results

Mean E2E errors ± 1 SD (RMS) were 0.13 ± 0.26 (0.28), 0.19 ± 0.17 (0.25), -0.09 ± 0.14 (0.16) mm in Superior-Inferior (SI), Right-Left (RL), Anterior-Posterior (AP) directions, respectively. Combined SD of intrafraction errors was 0.07, 0.10 and 0.11 mm (SI, RL, AP). SD of GTV delineation/MRI-CT registration errors was 0.29, 0.28, 0.30 / 0.57, 0.33, 0.32 mm (SI, RL, AP). σ_p was 3.60 mm. AL-TL-based anisotropic 6DST SMs was 1.8, 1.3, 1.2 mm (SI, RL, AP). Allowing R.18.TL, results in SMs 2.2, 1.9, 1.9 mm (SI, RL, AP). Implementation of two-level E2E tolerances resulted in reduction of PTV/GTV volume ratio by 24% for 1.0 cm, 14% for 2.0 cm and 8% for 4.0 cm diameter spherical GTV, respectively.

Conclusion

Establishing TL additional to AL in SRS/SRT QC allows substantial reduction of SMs. This translates in substantial decrease in PTV shell volumes, especially for smaller GTVs, which may be especially important for patients receiving biological therapy in addition to SRS/SRT.

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