

From Couch-Kick Verification to Continuous Monitoring: Evaluating ExacTrac Dynamic in Frameless Single-Isocenter Multi-Target SRS

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Purpose

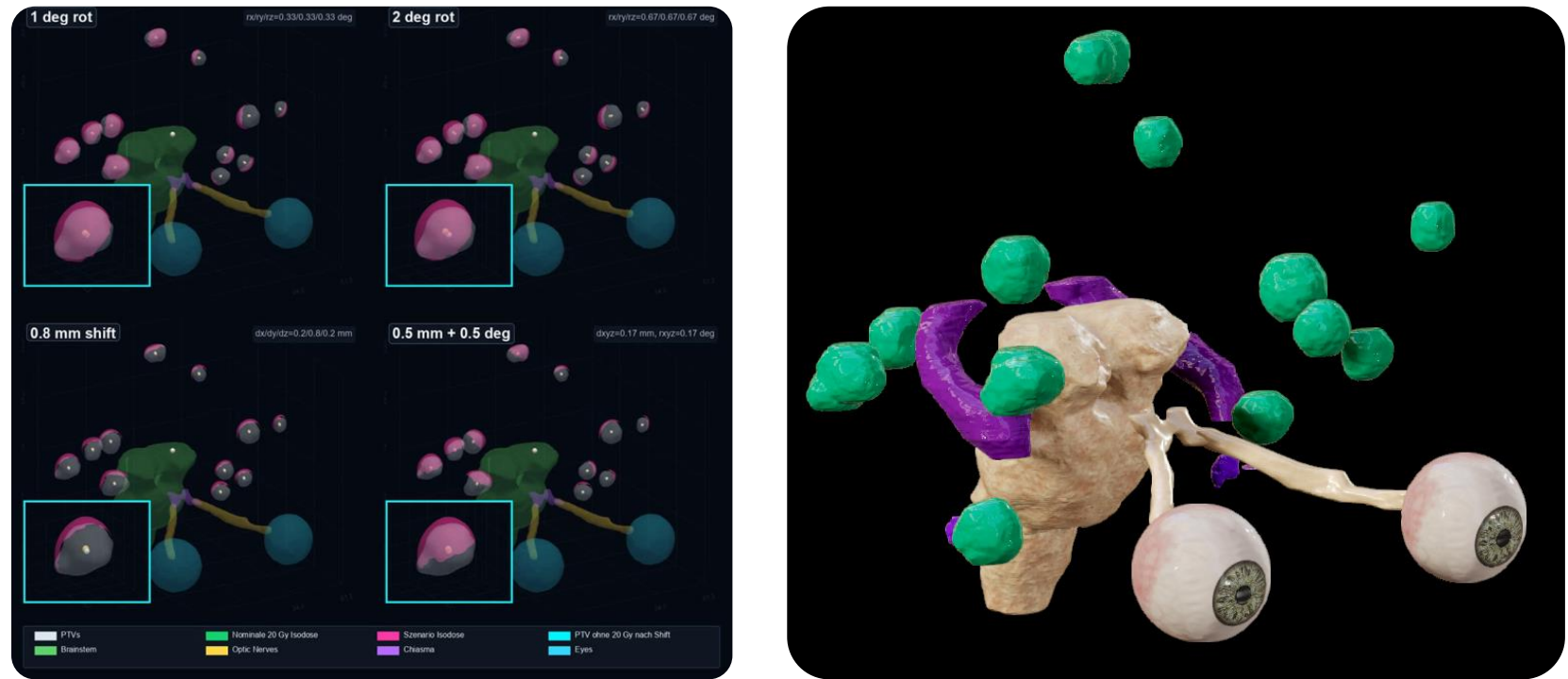
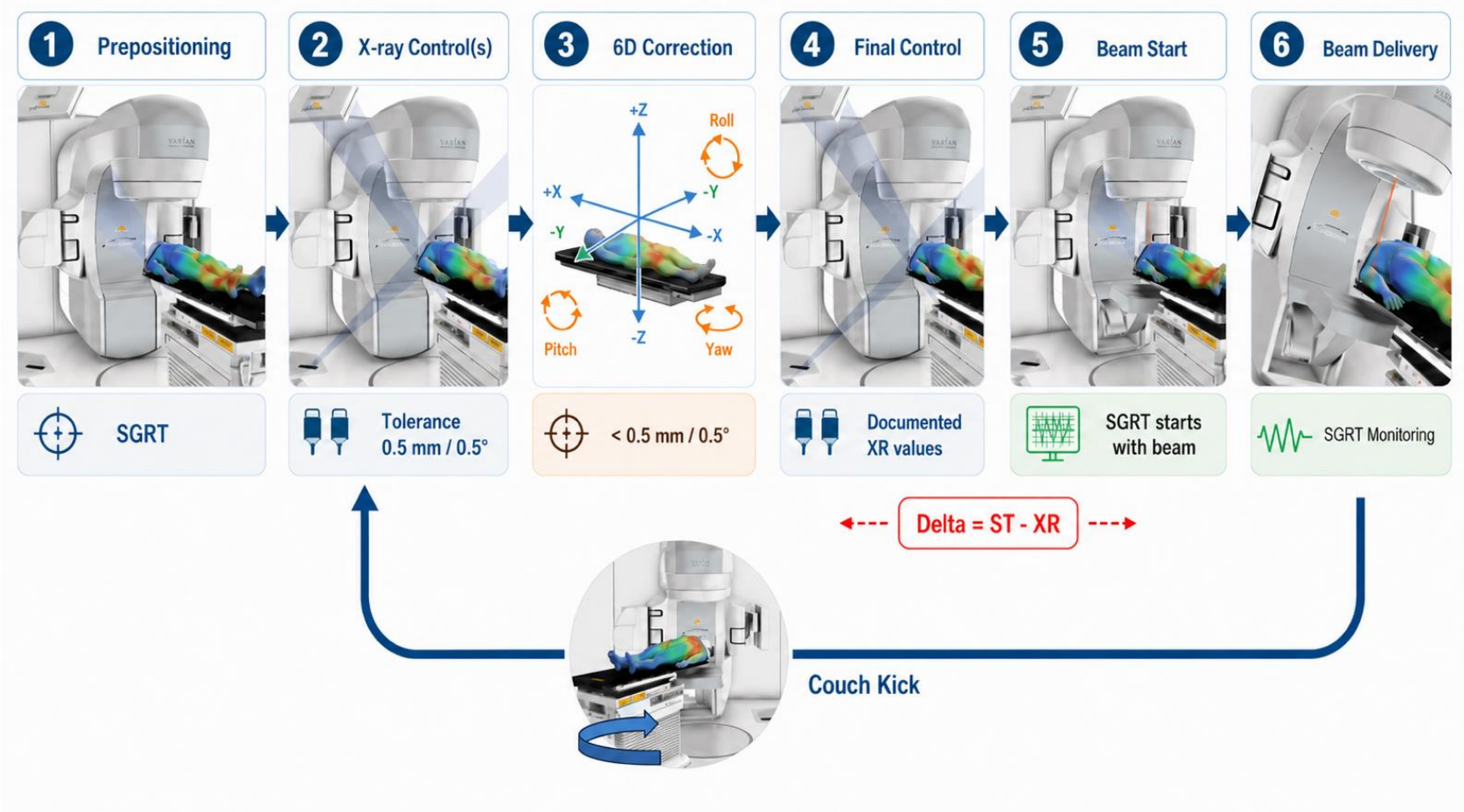
In C-arm linac frameless single-isocenter multi-target stereotactic radiosurgery, couch rotations repeatedly change the geometric relationship between patient, imaging system, surface camera and beam. We evaluated how often post-couch-kick X-ray verification triggers correction, how closely SGRT agrees with the last X-ray before irradiation, and whether residual 6D differences have plausible dosimetric relevance.

Materials and Methods

ARIA treatment-field and couch events were linked to ExacTrac X-ray pairs and SGRT data. Each session was reconstructed as repeated couch-angle sequences: SGRT prepositioning, X-ray control(s), 6D correction if required, final X-ray with documented residuals, beam start with SGRT onset, and continuous monitoring during delivery. The first couch angle was excluded. The comparison used the final X-ray before beam start and the SGRT value at monitoring start; ST–XR was calculated in all six dimensions. The cohort comprised 2,908 head multi-couch sessions from 565 patients (2020-01-01 to 2026-07-01). Of 3,456 reconstructed beam-start rows, 2,295 remained after excluding the first couch angle; 1,078 had complete 6D data. ETD–XR tolerances were 0.3–0.5 mm and 0.3–0.5°.

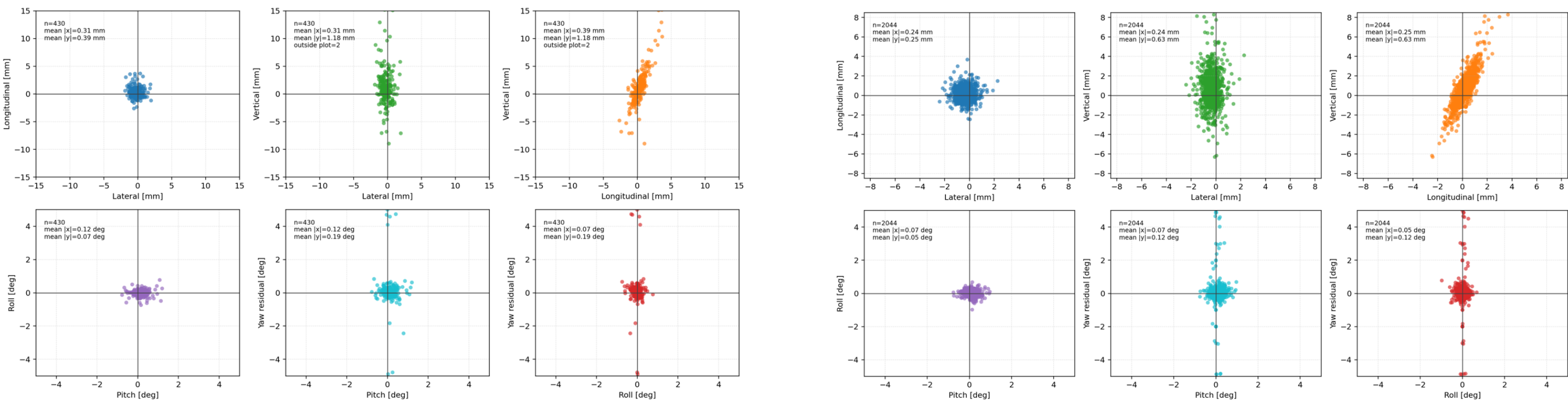
Conclusion

More than half of couch rotations required additional 6D correction. Longer delays increased residual ST–XR differences. Continuous SGRT adds a complementary safety layer after final X-ray verification.

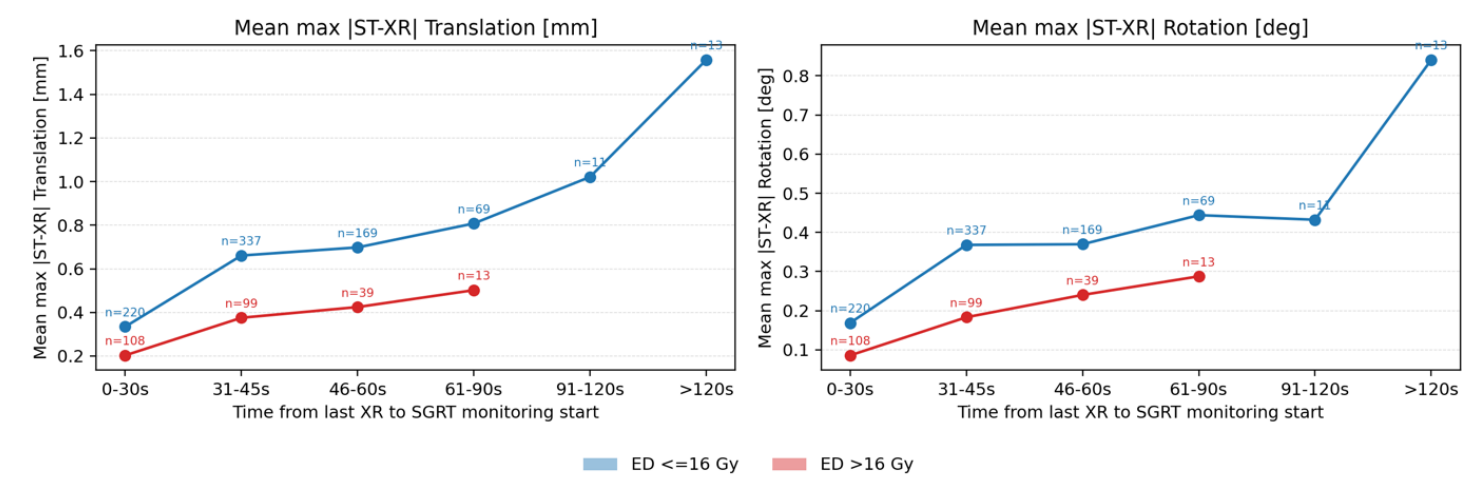


Results

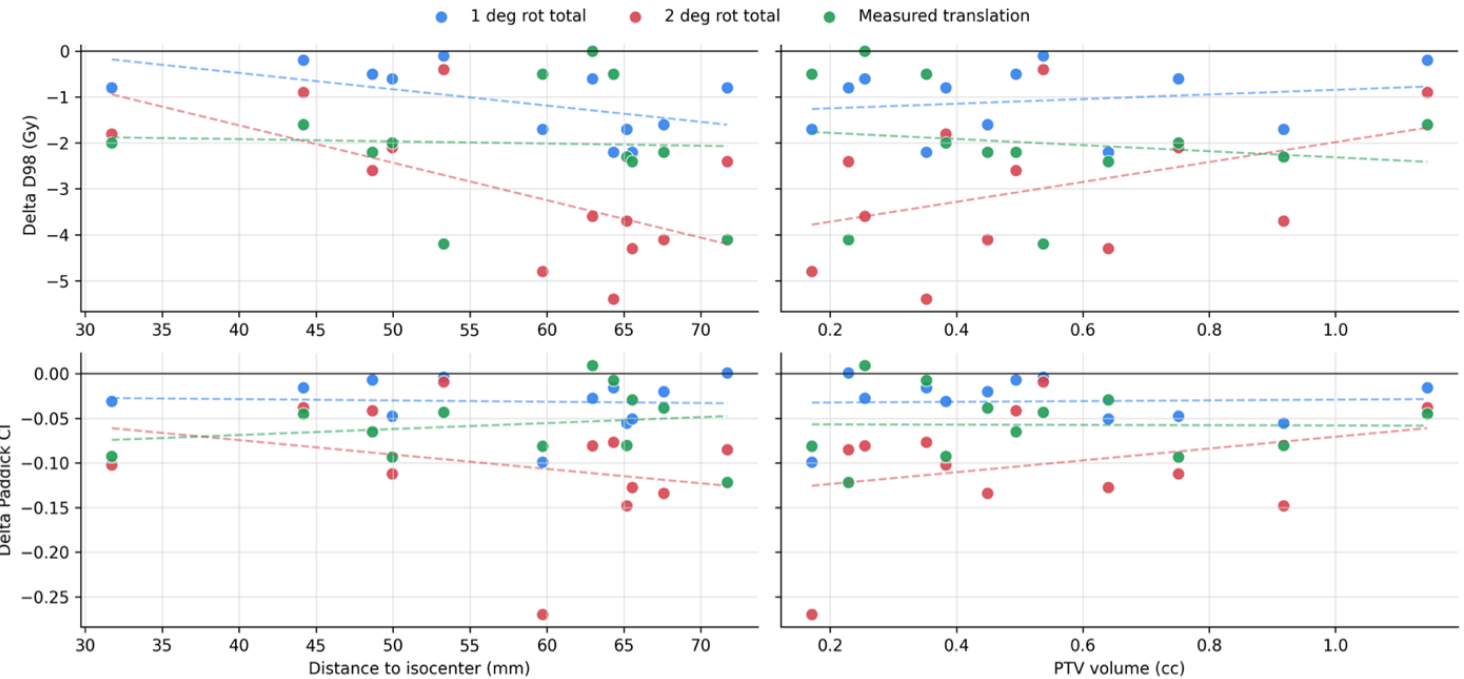
Post-couch-kick verification remained frequently relevant: additional 6D correction after couch rotation was documented in 51.8% of SRS sessions (ED >16 Gy; 930/1,794) and 64.1% of FSRT sessions (ED ≤16 Gy; 1,976/3,085). Final X-ray and SGRT at beam start were broadly consistent but not interchangeable. The evidence panels show the workflow, ARIA-derived correction vectors, direct ST–XR differences, timing dependence and exploratory dose impact.



ARIA-derived post-couch-kick 6D corrections. Pairwise translational and rotational correction components after couch rotation, showing the magnitude and directionality of couch shifts required before treatment delivery. Left: FSRT, Right: SRS



Timing effect between final X-ray and SGRT/beam start. Mean maximum ST–XR differences increase with longer intervals between final X-ray verification and SGRT monitoring start, suggesting that workflow timing contributes to observed system differences.



Direct ST–XR system differences. Two-dimensional distributions of SGRT minus final X-ray residuals at beam start. The origin represents identical readings by both systems; distance from the origin reflects residual system disagreement.

Exploratory dose-impact analysis. Pilot estimation of potential dosimetric relevance of measured residual translations and simulated rotations as a function of target distance from isocenter and target volume.