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Topic (read-only)

Physics: Inter-fraction motion management and daily adaptive radiotherapy

Keywords (read-only)

Synthetic-CT, adaptive, pelvis male

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Abstract title (read-only)

Diffusion-based synthetic-CT generation from pelvis male CBCT

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Purpose/Objective (read-only)

Cone-beam CT (CBCT) imaging is routinely used in radiation therapy for patient positioning, but its broader clinical application remains limited by suboptimal image quality, spatial resolution, and field of view. Extending CBCT beyond setup verification could substantially advance adaptive radiotherapy. Achieving this requires enhanced image fidelity to support accurate organ-at-risk delineation, precise dose computation, and adaptive treatment replanning. This study presents and clinically validates an artificial intelligence (AI)–based framework that generates high-quality synthetic CT (sCT) images directly from CBCT scans. By addressing key CBCT limitations, the proposed approach demonstrates strong potential to enable fully CBCT-driven adaptive radiotherapy for pelvic male cancer patients.

Material/Methods (read-only)

Developing a 3D multimodal translation model for medical imaging presents challenges, including the computational demands of volumetric data, the scarcity of high-quality paired datasets, and the need to maintain quantitative accuracy for clinical use. To address these, a 3D

conditioning strategy was employed to ensure anatomical consistency and quantitative reliability of the generated images. The unsupervised model was trained on approximately 34,000 CT scans (50% pelvis, 37.5% head and neck, 12.5% thorax) to ensure anatomical diversity, followed by fine-tuning with 325 pelvic male cancer patients (3,406 paired datasets).

For clinical evaluation, an independent cohort of 20 pelvic male cancer patients treated across three European cancer centres was selected. Planning CTs were deformably registered to CBCTs (warped CTs, wCTs) to account for anatomical and positional variations. Treatment plans were re-optimised and recalculated on both wCTs and sCTs for dosimetric comparison.

Results (read-only)

Median relative differences in dose–volume histogram (DVH) parameters between sCTs and wCTs were minimal (0.12–0.21% - Table 1), with the largest difference for D2% (0.21%) and the lowest for Dmean and D98% (0.12%). Median gamma pass rates reached 99.99% (2%/2 mm) and 100% (3%/3 mm) at a 1% low-dose threshold (Table 2), confirming excellent dosimetric agreement.

Structure	DVH parameter	Median relative difference (%)
Target volumes	Dmax [Gy]	0.20
	Dmean [Gy]	0.12
	D2% [Gy]	0.21
	D5% [Gy]	0.19
	D50% [Gy]	0.13
	D95% [Gy]	0.13
	D98% [Gy]	0.12

Gamma index	2%/2mm			3%/3mm		
Low dose threshold	1%	10%	20%	1%	10%	20%
Median	99.99	99.99	100	100	100	100

Conclusion (read-only)

This study demonstrates the feasibility and accuracy of AI-generated sCTs from CBCT images in pelvic male cancer radiotherapy. The results confirm their potential to enhance adaptive planning, streamline clinical workflows, and support fully CBCT-based personalised radiotherapy.

Conflict of Interest Disclosure (read-only)

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- ( ) I do have a Conflict of Interest to disclose.

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