OPEN ACCESS Freely available online

Chemotherapy: Open Access
ISSN: 2167-7700

Perspective

Integration of Artificial Intelligence and Advanced Imaging in Radiotherapy Treatment Planning

Rebecca Chen[*]

Department of Radiation Oncology and Medical Imaging, Faculty of Medicine, Pacific Health Sciences University, Vancouver, Canada

DESCRIPTION

The integration of Artificial Intelligence (AI) and advanced imaging technologies into radiotherapy treatment planning represents a paradigm shift in the delivery of cancer care, driving improvements in precision, efficiency and clinical outcomes. Radiotherapy has long relied on accurate delineation of tumor volumes and critical structures, optimal dose distribution and effective adaptation to anatomical changes over the course of treatment. Historically, these tasks have been labor-intensive and subject to variability based on clinician expertise. In recent years, the emergence of AI, particularly machine learning and deep learning algorithms, alongside advanced imaging modalities such as functional MRI, Positron Emission Tomography (PET-CT) and 4D-CT, has transformed how clinicians approach each step of the radiotherapy planning process. By harnessing the power of computational intelligence and high-resolution imaging data, treatment planning has become more personalized, consistent and responsive to the dynamic nature of tumor biology and patient anatomy.

At the core of radiotherapy planning is the process of image segmentation, where target tumors and surrounding Organs At Risk (OARs) are identified and contoured on imaging studies. Traditionally, this task has been performed manually by radiation oncologists and dosimetrists, often requiring hours of meticulous work. AI-driven auto-segmentation tools now offer remarkable improvements in speed and reproducibility. Using convolutional neural networks trained on large datasets of expertly annotated images, these systems can automatically delineate tumors and OARs with accuracy approaching that of human experts. This not only reduces planning time but also minimizes inter-observer variability, ensuring a more standardized approach across patients and institutions. Enhanced contouring accuracy is particularly valuable in complex anatomical regions like the head and neck or pelvis where subtle differences in contours can significantly affect dose distributions and toxicity.

Advanced imaging modalities further augment the quality of treatment planning by providing rich functional and structural information that goes beyond conventional CT imaging. Positron Emission Tomography (PET), for example, reveals metabolic activity indicative of tumor aggressiveness, while diffusion-weighted MRI offers insights into tissue cellularity and 4D-CT captures respiratory motion in thoracic and abdominal tumors. When integrated with AI analytics, these modalities enable biologically informed treatment plans that can tailor radiation doses to sub-regions of tumors with higher metabolic activity or radioresistant characteristics. AI algorithms can assimilate multi-modal imaging data to define biological target volumes that reflect not just anatomical extent but also phenotypic behavior of the tumor, potentially improving local control while sparing healthy tissues.

Another area where AI and advanced imaging intersect is in Adaptive Radiotherapy (ART). Tumor shrinkage, anatomical changes and weight loss during a treatment course can alter the spatial relationships between the tumor and surrounding organs. Traditionally, re-planning to accommodate these changes required additional imaging and manual recontouring, delaying interventions. AI-driven adaptive planning systems, paired with daily imaging such as cone-beam CT or MRI-guided radiotherapy, can rapidly re-segment anatomy and adjust dose distributions in near real-time. These systems use predictive models to anticipate anatomical changes and recommend adjusted plans that maintain target coverage and respect dose constraints for normal tissues. By facilitating dynamic treatment adaptation, AI enhances the ability to deliver high-precision radiation throughout the entire course of therapy, potentially improving outcomes and reducing side effects.

Treatment plan optimization itself has also benefited from AI integration. Traditional optimization relies on iterative algorithms that balance target coverage with normal tissue sparing based on predefined constraints. Machine learning models, trained on thousands of high-quality clinical plans, can predict optimal dose–volume histograms and guide planners toward superior solutions more efficiently. These AI-assisted

Correspondence to: Rebecca Chen, Department of Radiation Oncology and Medical Imaging, Faculty of Medicine, Pacific Health Sciences University, Vancouver, Canada, E-mail: rebecca.chen@phsu.edu

Received: 30-Jun -2025, Manuscript No. CMT-25-40405; **Editor assigned:** 03-Jul-2025, PreQC No. CMT-25-40405 (PQ); **Reviewed:** 17-Jul -2025, QC No. CMT-25-40405; **Revised:** 25-Jul -2025, Manuscript No. CMT-25-40405 (R); **Published:** 02-Aug -2025, DOI: 10.35248/2167-770.25.12.227

Citation: Chen R (2025) Integration of Artificial Intelligence and Advanced Imaging in Radiotherapy Treatment Planning. Chemo Open Access. 12:227.

planning engines can suggest beam angles, intensity patterns and dose distributions customized to the patient's unique anatomy and tumor characteristics, reducing planning time and enhancing plan quality. The result is a more streamlined workflow that allows clinicians to focus on decision-making rather than repetitive technical adjustments.

Despite the substantial promise of AI and advanced imaging, challenges remain in their clinical implementation. High-quality annotated data are essential for training robust AI models, yet data sharing across institutions can be constrained by privacy concerns and variations in imaging protocols. Furthermore, regulatory frameworks for AI-based medical tools are still evolving, requiring rigorous validation and continuous monitoring to ensure safety and effectiveness. Clinician acceptance and the need for specialized training to interpret AI outputs are also important considerations, as the technology must complement-not replace human expertise.

CONCLUSION

In conclusion, the integration of artificial intelligence and advanced imaging in radiotherapy treatment planning is reshaping modern oncology by enhancing accuracy, efficiency and personalization. From automated segmentation and biologically informed planning to adaptive therapies and AI-guided optimization, these technologies promise to elevate the standard of care for cancer patients worldwide. Ongoing research, interdisciplinary collaboration and thoughtful implementation strategies will be critical to fully realizing the potential of AI and advanced imaging, ensuring that radiotherapy continues to evolve in sophistication and patient-centered effectiveness.