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Commentary

Human–AI Collaboration in Radiotherapy: Redefining the Role of Radiation Oncologists

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The rapid integration of artificial intelligence (AI) into radiotherapy is reshaping a discipline long defined by human expertise and experience [1]. Over the past decade, AI has moved from isolated applications in image processing to a pervasive presence across the radiotherapy workflow, spanning image reconstruction, contouring, treatment planning, and outcome prediction [1]. Much of the early discussion has focused on efficiency gains and workflow standardization. Yet a more fundamental shift is now underway. AI is beginning to influence how clinical decisions are made, raising a deeper question about whether the role of radiation oncologists itself is being redefined.

The trajectory of AI development in radiotherapy reveals a gradual but meaningful expansion in its functional role. Early implementations were largely confined to automating repetitive and time-consuming tasks. Auto-segmentation algorithms based on deep learning, for instance, have achieved near-human performance in delineating organs at risk and certain target volumes, significantly reducing contouring time while improving consistency [2]. In this context, AI functioned primarily as a technical aid. Clinical reasoning and decision-making remained firmly under human control.

This boundary has become less distinct with the emergence of AI-driven treatment planning. Recent multicenter evidence demonstrates that automated planning systems can generate clinically acceptable plans in the majority of cases, with a substantial proportion even preferred over manually created plans in blinded evaluations [3]. These findings suggest that AI is no longer limited to assisting with discrete tasks but is capable of handling complex optimization processes traditionally guided by clinician expertise. Treatment planning is inherently a problem of balancing competing priorities, including tumor control and normal tissue preservation. The ability of AI to navigate these trade-offs challenges the assumption that such decisions must be exclusively human-driven.

The expansion of AI into decision-support roles is even more evident in adaptive radiotherapy. Determining when to trigger replanning in online adaptive radiotherapy has historically depended on subjective image assessment, often accompanied by considerable interobserver variability. Recent studies indicate that AI models can identify fractions requiring adaptation with accuracy comparable to, and in some respects exceeding, physician consensus [4]. When algorithms begin to inform decisions that directly alter treatment delivery, the distinction between assistance and participation becomes increasingly blurred.

Despite these advances, the growing influence of AI does not equate to the obsolescence of radiation oncologists. Instead, it exposes the limitations of current systems and highlights the continued importance of human judgment. One persistent challenge lies in generalizability. Variations in patient populations, imaging protocols, and institutional practices can significantly affect AI performance. Even in carefully designed multicenter studies, acceptance rates of AI-generated plans vary across institutions, reflecting the difficulty of translating algorithmic success into consistent real-world applicability.

Another limitation emerges at the level of individual patient care. AI models tend to perform well when evaluated against population-level metrics, yet radiotherapy decisions are rarely made in such abstract terms. Subtle clinical considerations, including patient comorbidities, anatomical variations, and physician preferences, often influence how trade-offs are resolved. These nuances are not always captured in training data, and as a result, AI-generated solutions may fall short when confronted with atypical or complex cases. The need for clinician oversight becomes particularly evident in these scenarios.

Concerns about interpretability further complicate the integration of AI into clinical practice. Many high-performing models operate as opaque systems, offering limited insight into how specific outputs are generated. In a field where treatment decisions carry significant consequences, this lack of transparency can undermine trust. Clinicians are unlikely to rely on recommendations that cannot be meaningfully interrogated or explained. Efforts to improve model interpretability are therefore essential for bridging the gap between technical performance and clinical acceptance.

Beyond these technical considerations, the presence of AI is subtly reshaping how clinicians engage with their work. Tasks that once required direct manual input are increasingly delegated to automated systems. This shift does not eliminate the clinician's role but alters its nature. The radiation oncologist is becoming less of a producer of plans and more of an evaluator of outputs. Responsibilities are moving toward oversight, validation, and the integration of AI-generated information into a broader clinical context.

This transition carries both opportunities and risks. On one hand, reducing the burden of repetitive tasks may allow clinicians to focus more on patient-centered aspects of care and complex decision-making. On the other, there is a risk that overreliance on AI could erode critical skills. The phenomenon of automation bias, in which individuals place undue trust in algorithmic outputs, has been observed in other domains and is likely relevant in radiotherapy as well. Maintaining a critical perspective toward AI recommendations is essential to prevent errors from being amplified rather than mitigated.

The implications of this transformation extend to medical education. Training programs have traditionally emphasized anatomical knowledge, technical proficiency, and experiential learning. While these remain important, they are no longer sufficient in isolation. Future radiation oncologists will need to understand how AI systems are developed, what their limitations are, and how to interpret their

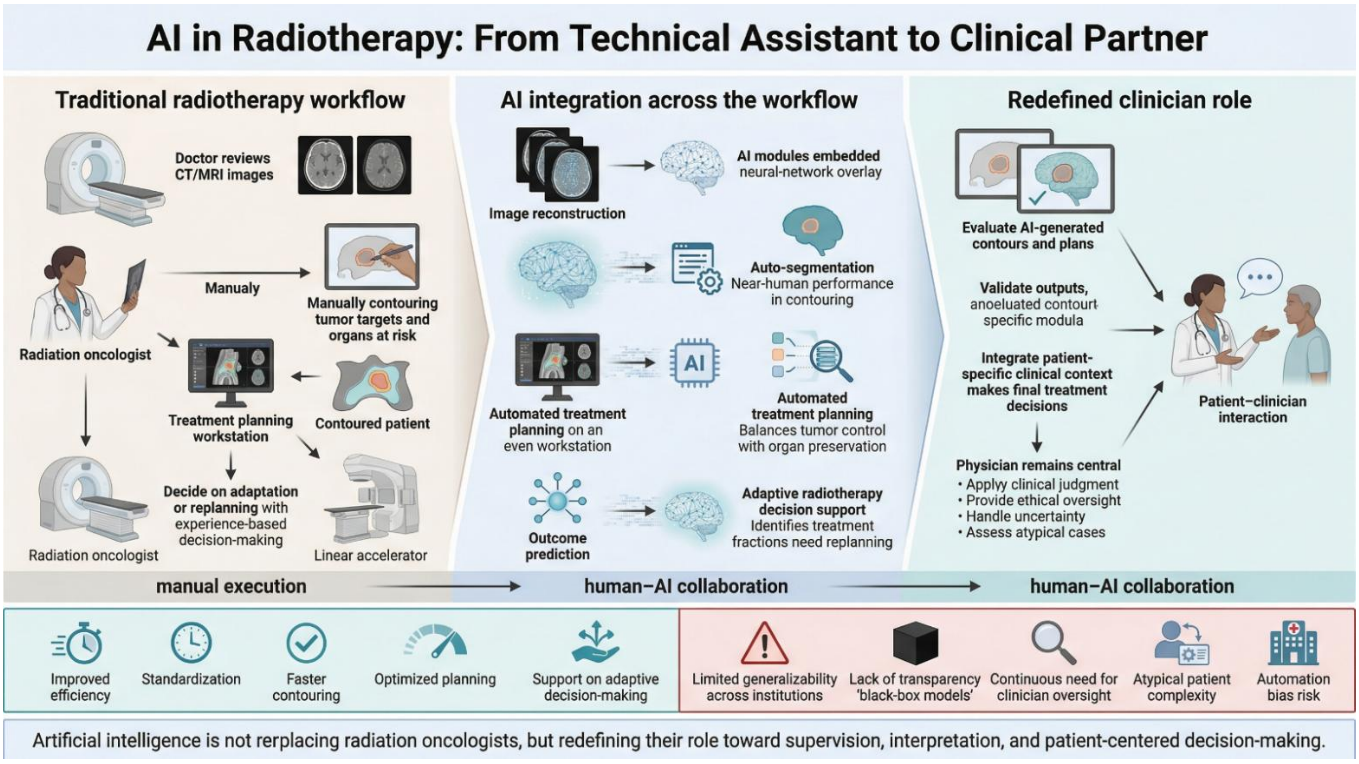

Figure 1. Conceptual overview of how artificial intelligence is reshaping radiotherapy from a predominantly manual, experience-driven process to an integrated human–AI collaborative model. AI systems are increasingly embedded across the workflow—from image reconstruction and auto-segmentation to treatment planning, outcome prediction, and adaptive decision support—enabling greater efficiency, standardization, and optimization. At the same time, this technological shift is redefining the role of radiation oncologists from direct task execution toward oversight, validation, and context-aware decision-making. While AI enhances performance and scalability, challenges related to generalizability, interpretability, and automation bias underscore the continued centrality of clinician judgment. Together, the model highlights a transition toward partnership, in which AI augments but does not replace clinical expertise.

outputs in a clinical setting. The ability to collaborate with data scientists and engineers may become as important as traditional clinical skills.

Taken together, these developments suggest that AI is not replacing radiation oncologists but redefining their role within an evolving technological ecosystem. The emerging model is one of collaboration rather than substitution. AI systems excel at processing large volumes of data, identifying patterns, and performing optimization at scale. Clinicians, in contrast, bring contextual understanding, ethical judgment, and the ability to navigate uncertainty. Combining these strengths has the potential to enhance both the efficiency and quality of care.

Achieving this balance will require deliberate effort. Improving the robustness of AI systems across diverse clinical settings remains a priority. Greater transparency in model design and decision-making processes will be necessary to build trust. At the same time, healthcare systems must adapt to incorporate AI in a way that supports, rather than diminishes, clinician expertise. Regulatory frameworks will need to address questions of accountability, particularly in situations where AI influences clinical decisions.

The question, therefore, is not whether AI will replace radiation oncologists, but how the profession will evolve in response to its growing presence. The integration of AI into radiotherapy represents not only a technological advancement but also a shift in how expertise is defined. In this new landscape, the value of the clinician lies not in performing every task manually, but in understanding when and how to rely on technology, and when to question it.

In this sense, AI can be viewed less as a competitor and more as a catalyst. It challenges existing practices, exposes inefficiencies, and compels a reevaluation of established roles. Whether this leads to a more effective and patient-centered model of care will depend largely on how clinicians engage with the technology. The future of radiotherapy is unlikely to be dominated by either humans or machines alone, but by a dynamic interaction between the two.

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Author Contributions

Y.S. and X.D. conceived the initial concept for this manuscript. Y.S. Z.Z. and X.G. wrote the first draft of the manuscript. X.D. revised the manuscript. All authors contributed to and approved the manuscript.

Declaration of competing interest

The authors declare that they have no conflict of interest.

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