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LETTER TO THE EDITOR

Radiomics-based Artificial Intelligence in Rectal Cancer: Pathway to Surgical Integration

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Dear Editor,

Accurate evaluation of tumor response after neoadjuvant chemoradiotherapy (nCRT) is pivotal in managing locally advanced rectal cancer. Identifying patients who achieve a pathological complete response (pCR) enables the implementation of organ-preserving strategies such as watch and wait, thereby reducing morbidity and improving quality of life. Because pCR is linked to survival and lower recurrence, precise prediction is essential. However, conventional tools, such as clinical examination, endoscopy, and magnetic resonance imaging (MRI), show limited sensitivity and considerable interobserver variation, and optimized MRI fails to distinguish clinical from true pCR, complicating surgical decision-making.[1,2]

Radiomics offers a promising solution by extracting quantitative MRI-based features that yield biomarkers of tumor heterogeneity and treatment-related change. Machine learning analyzes these data, detecting texture, entropy, or morphologic patterns suggestive of residual disease, fibrosis, or necrosis. Such biomarkers refine the distinction between clinical and pathological response, although standardized methods and prospective validation remain prerequisites for clinical adoption.[3,4]

Evidence for radiomics is expanding rapidly. A recent meta-analysis encompassing over 10,000 patients across 35 studies reported a pooled area under the curve of approximately 0.87 for predicting pCR, highlighting promising potential but also marked heterogeneity among included datasets.[5] Bourbonne et al.[6] synthesized multicenter evidence supporting multiparametric MRI radiomics, and Feng et al.[7] developed a multicenter radio-pathomics model, externally and prospectively validated, demonstrating strong discrimination and careful calibration. El Homsi et al.[2] reported high-performance models incorporating deep learning within MRI radiomics. Crimì et al.[3] confirmed the added value of diffusion-weighted imaging, whereas Wang et al.[4] suggested that preprocessing variations may have only limited impact on predictive performance. Collectively, these studies underscore both the promise and the fragility of current approaches.

Post-treatment imaging has also been investigated. Lee et al.[8] demonstrated that post-nCRT T2 radiomics correlated with tumor regression grade, guiding non-operative selection. Meng et al.[9] built a multi-sequence multi-regional model for lymph node metastasis, complementing risk stratification, and Peng introduced spatiotemporal radiomics to refine surgical timing.[10]

Despite encouraging progress, substantial barriers remain. The absence of standardized imaging protocols, consistent segmentation techniques, and unified feature extraction pipelines continues to limit reproducibility across institutions. Although frameworks such as the Transparent Reporting of a multivariable prediction model for Individual Prognosis or Diagnosis - Artificial Intelligence (AI), the Radiomics Quality

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Score, and the Checklist for AI in Medical Imaging have been developed to promote methodological transparency and standardization, adherence remains inconsistent. Most published studies are retrospective, single-center, and statistically underpowered for regulatory assessment. Interpretability also poses a challenge, as many algorithms operate as "black boxes," reducing clinicians confidence in their practical reliability. Early research by He and El Homsi suggests that temporal radiomics and explainable AI techniques, including attention mapping and feature saliency analyses, may enhance trust, yet these approaches remain underutilized. The principal obstacles to clinical translation involve the lack of standardized acquisition protocols, reproducible segmentation workflows, and harmonized feature extraction methods across centers. Effective clinical integration will ultimately depend on access to advanced imaging, reliable segmentation, automated analysis pipelines, and user-friendly interfaces embedded within routine healthcare systems.

From a surgical perspective, radiomics should augment decision-making rather than replace expertise. By providing objective biomarkers, these tools can refine surgical timing, tailor resections, and support non-operative strategies in selected patients. Future uses may include intraoperative navigation, integration with genomics and pathology, and personalized simulation platforms. Translation to clinical practice will depend less on algorithmic novelty than on rigorous validation, transparent reporting, and multidisciplinary integration. Radiomics-based AI is not a substitute for surgical judgment but a pathway toward more precise, individualized, and patient-centered rectal cancer management. The convergence of radiomics-based AI with digital pathology, molecular profiling, and intraoperative imaging may redefine precision surgery by transforming tumor assessment from static imaging into a dynamic understanding of disease biology. For surgeons, these advances offer a chance to shape future decision-making through data-driven, cross-disciplinary collaboration.

Footnotes

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