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Clinical Validation of Methods for Improving the Quality and Efficiency of Radiation Therapy Contouring Based on RT Contour QA

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ABSTRACT

Objective
To address the problems of cumbersome, time-consuming manual quality assurance processes that are prone to subjective experience influence, this study proposes an automated structure quality control method based on RT contour QA software.
Methods
A structure quality control link was embedded into the original radiotherapy workflow. RT contour QA provides six abnormality detection rules for radiotherapy structures: bad points, slice discontinuity, overlap, empty ROI, ROI hollowing, and volume anomalies. This study included the ROI delineation results of 551 radiotherapy patients with six common cancer types such as nasopharyngeal carcinoma and rectal cancer in the past two years, which were divided into three periods: H1 2024, H2 2024, and H1 2025. The software was used to detect abnormality types across periods, compare their changing trends, and retrospectively evaluate its quality control effectiveness.
Results
From H1 2024 to H1 2025, the overall quality showed a stepwise improvement. Among the six cancer types, rectal cancer had the most significant quality control improvement, with the average number of abnormality types decreasing by 45.28% year-on-year, followed by lung cancer and cervical cancer. Among the abnormality types, the incidence rate of ROI hollowing dropped to 0%, and empty ROI and bad points improved relatively significantly.
Conclusion
This study confirms that this automated quality control software can quickly identify potential abnormalities in delineation and provide clear modification suggestions for manually delineated contours, which is of great value for improving the precision level of radiotherapy.

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INTRODUCTION

In radiation therapy planning, the precise delineation of Regions of Interest (ROIs), particularly the contours of Organs at Risk (OARs), is critically important for ensuring dose accuracy and treatment safety.The current clinical workflow for radiation therapy structure delineation generally consists of automatic segmentation followed by manual review and correction by physicians. Common issues with automatic segmentation include data bias, misjudgment caused by artifact interference, missed detection of small lesions, and inaccurate delineation of irregular morphological edges. However, when physicians manually inspect each organ structure of a patient, omissions or operational errors may still occur. For instance, physicians' subjective judgment biases, over-reliance on their own past experience, knowledge gaps in anatomy, as well as human errors or improper tool usage, can all result in abnormal ROI delineation.

To address this problem, this study integrates **RT contour QA** quality control software into the routine radiation therapy workflow to identify common abnormalities in delineation through automated detection methods. The purpose is to evaluate the clinical value of this approach in enhancing the quality and efficiency of radiation therapy structure delineation, and to provide evidence for establishing a standardized and intelligent radiation therapy quality control system.

METHODS AND MATERIALS

This study employed RT contour QA quality control software, which can automatically analyze and compare radiation therapy structures based on predefined standards. It is capable of automatically identifying six common delineation errors: **bad points, slice discontinuity, overlap, empty ROI, ROI hollowing, and volume anomalies,** and ultimately generates a detailed report on structural analysis and quality control.
This study retrospectively enrolled 551 patients who received radiation therapy at our hospital from January 2024 to June 2025, covering six clinically prevalent cancer types: nasopharyngeal carcinoma, rectal cancer, breast cancer, lung cancer, esophageal cancer, and cervical cancer. Patients were divided into three groups according to treatment time (six months per period): 169 cases in H1 2024, 239 cases in H2 2024, and 143 cases in H1 2025.
Descriptive statistical methods were used to analyze the data, and the changing trends of the three-period data were compared to evaluate the sustainability and stability of the quality control effectiveness.

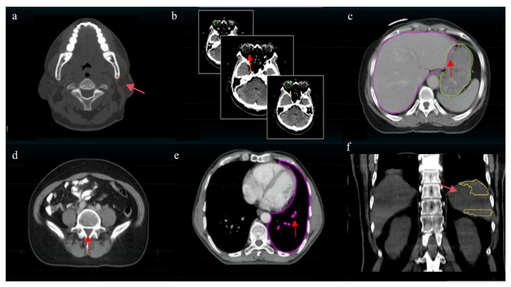

Figure 1. Example Images of Six Types of Structural Abnormality Problems.

RESULTS

Overall Quality Control Effectiveness
From H1 2024 to H1 2025, the overall quality of radiation therapy structure delineation exhibited a stepwise improvement. The overall abnormality rate continued to decline, and the average number of abnormality types dropped from 2.25 to 1.79 and then to 1.66, with the quality control effect stabilizing in the later period.

Quality Control Differences Across Cancer Types
Quality control outcomes showed varying degrees of improvement across different cancer types (Table 1). Among them, rectal cancer demonstrated the most remarkable improvement, with the average number of abnormality types decreasing by 45.28% year-on-year and the abnormality rate falling from 100% to 84%. Lung cancer and cervical cancer followed in order. The average number of abnormality types for nasopharyngeal carcinoma, breast cancer, and esophageal cancer also decreased to varying extents.

Improvement of Different Abnormality Types
Among the six types of abnormalities, ROI hollowing showed the most thorough improvement, with its incidence rate dropping to 0% in H1 2025. Empty ROI and bad points also improved significantly, while the incidence rates of slice discontinuity and overlap abnormalities showed no obvious improvement (Table 2). Further analysis revealed that these two types of abnormalities are mostly caused by the inherent anatomical characteristics of the organs, such as natural overlap between adjacent organs and segmented delineation of target volumes. Moreover, they have minimal and negligible impact on clinical treatment.

Table 1. Statistical results of cancer type structural abnormalities.

Indicator	Case Number			Abnormality Rate (%)			Mean Number of Abnormal(types/case)		
Cancer Type	2024H1	2024H2	2025H1	2024H1	2024H2	2025H1	2024H1	2024H2	2025H1
Nasopharyngeal Carcinoma	31	34	32	100	100	87.5	2.65	2.06	2.09
Rectal Cancer	25	25	25	100	96	84	2.12	1.68	1.16
Breast Cancer	30	79	28	100	100	100	2.3	1.91	1.93
Lung Cancer	48	35	24	97.92	97.14	100	2.25	1.46	1.54
Esophageal Cancer	17	14	16	100	100	100	2.53	2.29	2
Cervical Cancer	18	52	18	100	100	100	1.67	1.35	1.22
Total	169	239	143	99.41	99.16	94.41	2.28	1.74	1.685

Table 2. Statistical Results of Structural Abnormality Types.

Indicator	Case Number			Abnormality Rate (%)		
Abnormal Types	2024H1	2024H2	2025H1	2024H1	2024H2	2025H1
bad points	96	27	23	56.8	11.30	16.08
Slice discontinuity	49	64	41	28.99	26.78	28.67
overlaps	167	237	134	98.82	99.16	93.71
empty ROIs	11	2	2	6.51	0.84	1.40
ROI hollowing	12	1	0	7.10	0.42	0.00
volume anomalies	50	85	41	29.59	35.56	28.67

DISCUSSION

The results of this study demonstrate that integrating RT contour QA software into the routine radiation therapy workflow has led to a continuous decline in the overall average number of abnormality types, confirming the effectiveness of automated quality control. Compared with manual review, automated quality control can provide immediate feedback on issues immediately after delineation is completed, allowing physicians to make timely corrections. This prevents errors from entering subsequent radiation therapy planning stages and significantly reduces the number of reworks.

ROI hollowing, empty ROI, and bad points are obvious technical errors that the software can accurately identify and locate, hence their improvement effects are remarkable. In contrast, slice discontinuity and overlap abnormalities are mostly caused by the inherent characteristics of anatomical structures. These abnormalities are not genuine delineation errors, so their incidence rates are difficult to significantly reduce through software detection. In subsequent software upgrades, it is necessary to optimize detection rules by integrating anatomical knowledge to reduce false positive results.

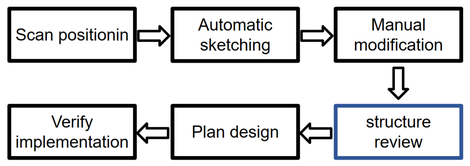

Figure 2. Optimized Structure QC Flowchart

CONCLUSIONS

This study demonstrates that RT contour QA automated quality control software can quickly and accurately identify common abnormalities in radiation therapy structure delineation, effectively enhance the quality and efficiency of delineation, and serves as a reliable adjunct tool for ROI delineation. Integrating it into the routine radiation therapy workflow can promote the standardization and precision of radiation therapy structure delineation, which is of great clinical significance for improving the quality of radiation therapy and ensuring patient safety.

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