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Inter-Institutional Comparison of Computed Tomography Dose Index and Half-Value Layer In Helical Kilovoltage Computed Tomography System for Tomotherapy (ClearRT)

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ABSTRACT

Purpose
To evaluate inter-institutional variability in the computed tomography dose index (CTDI) and aluminum half-value layer (HVL) of the ClearRT, and to assess the consistency of imaging dose and beam quality across institutions.
Methods
CTDI and HVL were measured at six institutions in Japan using the same dosimeter, X-ray analyzer, lead slit, and standard CTDI phantoms (16 cm and 32 cm diameter). The lead slit was used to restrict the incident X-ray beam to forward-incident X-rays only during HVL measurements. Identical scanning protocols, based on the manufacturer's acceptance testing procedures, were applied at all sites to minimize procedural variability.
Results
Three scanning protocols (head, thorax, and pelvis) were evaluated. The mean ± standard deviation values of helical $CTDI_{vol}$ across all participating institutions were 10.15 ± 0.18 mGy, 12.20 ± 0.21 mGy, and 10.72 ± 0.22 mGy, respectively. The corresponding HVL values were 8.63 ± 0.04 mmAl, 6.69 ± 0.05 mmAl, and 7.36 ± 0.08 mmAl. The maximum inter-institutional differences were 0.55 mGy (5.0%) for $CTDI_{vol}$ and 0.26 mmAl (3.5%) for HVL for the same imaging protocol.
Conclusion
Inter-institutional variability in helical $CTDI_{vol}$ and HVL for ClearRT was within the measurement uncertainty of the same dosimeter and X-ray analyzer. The observed variability was also within the tolerance levels recommended by the AAPM TG-198 QA guidelines. These results support consistent imaging dose and beam quality across institutions.

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Conflict of Interest
This study was supported by a research grant from RTQM System Co., Ltd.

INTRODUCTION

ClearRT is a helical kilovoltage (kV) computed tomography (CT) system integrated into the Radixact platform. Using a proprietary reconstruction algorithm, ClearRT reduces artifacts typically associated with cone-beam CT due to its fan-beam-like geometry and enables long scan lengths (up to 135 cm) with a large field of view (500 mm). Compared with conventional megavoltage CT (MVCT), it provides improved image quality, shorter acquisition time, and lower radiation dose [1].

ClearRT imaging protocols are selected based on predefined parameters such as anatomy, body size, field of view, and imaging mode. Because scan parameters (e.g., tube voltage, tube current, and pitch) cannot be manually adjusted, identical protocols are expected to produce consistent imaging dose and beam quality across institutions.

However, inter-institutional consistency of CTDI and HVL for ClearRT has not been well established. Furthermore, variability in CT-to-mass density (CT–MD) calibration tables has been reported among institutions in Japan, particularly in high-density regions [2]. Establishing consistency in CTDI and HVL could support nationwide standardization of dose evaluation and CT–MD calibration in image-guided radiotherapy (IGRT). Conversely, any observed variability would highlight the need for site-specific quality assurance.

Therefore, this study aims to investigate inter-institutional differences in CTDI and HVL for ClearRT under identical imaging protocols using standardized measurement methods.

METHODS AND MATERIALS

CTDI and HVL were measured using the same dosimeter and X-ray analyzer (RaySafe X2, Fluke Biomedical, Cleveland, OH, USA) with a lead slit (RTQM System Co., Ltd., Hiroshima, Japan) (Figure 1) and standard CTDI phantoms (16 cm and 32 cm diameter) (Figure 2).
CTDI and HVL measurements were performed at six independent institutions in Japan.
Although the CTDI measurement method is principally defined for non-helical scans, ClearRT supports only helical scanning. Therefore, following previous reports [3], helical $CTDI_{vol}$ was adopted as the evaluation metric.
The lead slit was used to restrict the incident X-ray beam to forward-incident X-rays only during HVL measurements.

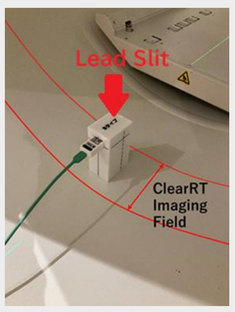


Figure 1. Lead Slit (HVL only)

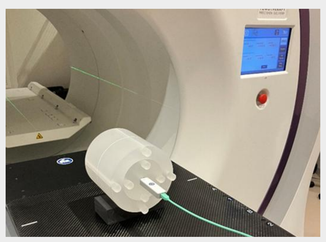


Figure 2. CTDI Phantom

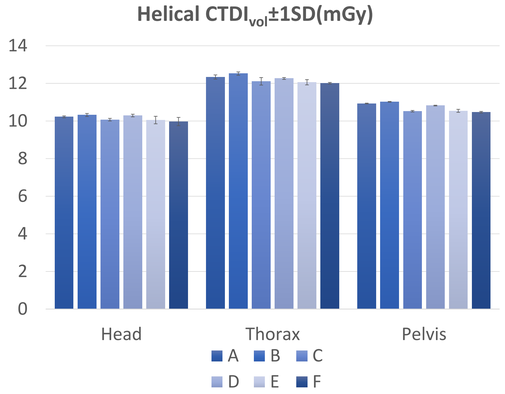
RESULTS

Three scanning protocols (head, thorax, and pelvis) were evaluated.
These protocols were selected based on the manufacturer's acceptance testing procedures.

Helical $CTDI_{vol}$ (mGy)

Protocol	Phantom	Mean ± SD (mGy)	Max Diff.
Head	16 cm	10.15 ± 0.18	3.5%
Thorax	32 cm	12.20 ± 0.21	4.1%
Pelvis	32 cm	10.72 ± 0.22	**5.0%**

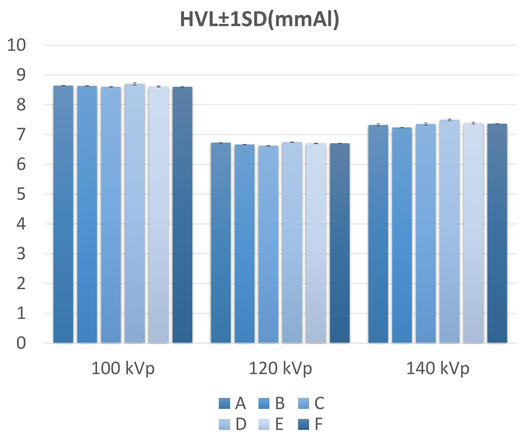
≤5.0%
Max inter-institutional difference in helical $CTDI_{vol}$



Aluminum Half-Value Layer (mmAl)

Protocol	Mean ± SD (mmAl)	Max Diff.
Head (100 kVp)	8.63 ± 0.04	1.6%
Thorax (120 kVp)	6.69 ± 0.05	1.8%
Pelvis (140 kVp)	7.36 ± 0.08	**3.5%**

≤3.5%
Max inter-institutional difference in HVL



DISCUSSION

The maximum inter-institutional differences were 0.55 mGy (5.0%) for helical $CTDI_{vol}$ and 0.26 mmAl (3.5%) for HVL under the same imaging protocol.

The observed differences were within the measurement uncertainty of the RaySafe X2 system (5% for dose and 10% for HVL measurements) [4]. They also remained well within the AAPM TG-198 recommended tolerance levels for kVCT imaging on linear accelerators (±20% from baseline for imaging dose and ±5% for beam quality/energy) [5]. Although the TG-198 guidelines are intended as longitudinal QA baseline tolerances, caution is warranted when applying them as criteria for inter-institutional comparisons.

These findings support the feasibility of multi-institutional QA for ClearRT, enabling reliable cross-institutional comparison of imaging dose and beam quality without site-specific calibration. Shared baseline values established through multi-institutional QA programs may also provide a more robust foundation for standardized QA and facilitate sharing of CTDI data and CT–MD calibration tables across institutions.

LIMITATIONS

This study included a limited number of institutions and did not evaluate all imaging protocols. Only three measurements were performed at each institution to minimize thermal loading of the X-ray tube. Further multi-institutional studies are warranted.

CONCLUSIONS

Inter-institutional variability in helical $CTDI_{vol}$ and HVL for ClearRT was within the measurement uncertainty of the same dosimeter and X-ray analyzer used in this study and within the tolerance levels recommended by the AAPM TG-198 QA guidelines.

These results support consistent imaging dose and beam quality across institutions.

REFERENCES

[1] Velten C, Goddard L, Jeong K, Garg MK, Tomé WA. Clinical Assessment of a Novel Ring Gantry Linear Accelerator-Mounted Helical Fan-Beam kVCT System. Adv Radiat Oncol 2022;7. https://doi.org/10.1016/j.adro.2021.100862.

[2] Tsunemine S, Ozawa S, Nakada R, Shiota Y, Kito S, Shimizu H, et al. Inter-institutional variability in CT-to-mass-density conversion tables for helical tomotherapy: a national survey in Japan. J Radiat Res 2025. https://doi.org/10.1093/jrr/rraf063.

[3] Leon SM, Kobistek RJ, Olguin EA, Zhang Z, Barreto IL, Schwarz BC. The helically-acquired $CTDI_{vol}$ as an alternative to traditional methodology. J Appl Clin Med Phys 2020;21:263–71.

[4] RaySafe. X2 Specifications Sheet, Fluke Biomedical, Cleveland, OH.

[5] Hanley J, Dresser S, Simon W, Flynn R, Klein EE, Letourneau D, et al. AAPM Task Group 198 Report: An implementation guide for TG 142 quality assurance of medical accelerators. Med Phys 2021;48:e830–85.