

INTRODUCTION

Background

The novel Varian **TrueBeam HyperSight-CBCT** (HS-CBCT), featuring **fast acquisition and iterative reconstruction**, aims to overcome image nonuniformity and artifacts in conventional CBCT. Radiomic analysis of on-treatment CBCT images holds great promise for adaptive prognostic modeling.

Limitations of Conventional CBCT

Conventional CBCT suffers from image **artifacts and instability**, which severely **undermine** feature reliability, as reported by Jha et al.¹⁾ Adachi et al. demonstrated that inter-protocol variations can reduce reproducibility by up to 37.5%, highlighting the urgent need for standardization.²⁾

Study Aim

Radiomic feature repeatability has been investigated for conventional CBCT, but the performance of HS-CBCT remains under-evaluated. This study is the first to evaluate the intra-day and inter-day repeatability of radiomic features in HS-CBCT images, using CT as a reference.

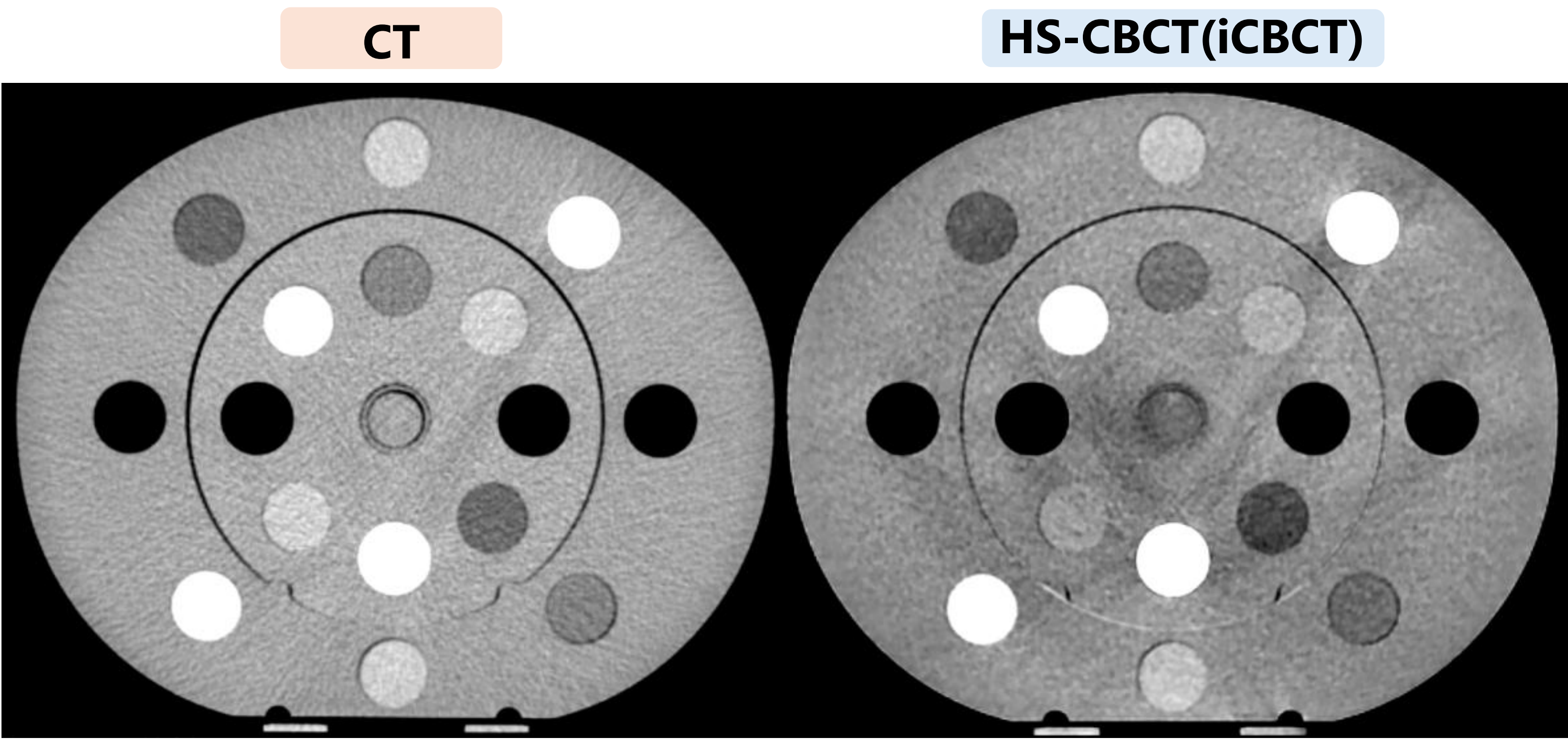


Figure.1:Representative images used in this study. Representative images used in this study. CT image and HS-CBCT image are shown.

METHODS

Phantom & Imaging

- CT-ED phantom with 16 tissue-equivalent inserts
- Acquisitions** Triplicate (intra-day); repeated across 3 days (inter-day)
- Tube voltage** CT: 100 & 120 kV / HS-CBCT: 100 & 125 kV
- Reconstruction** CT: FBP (Filtered Back Projection)
HS-CBCT: Feldkamp (FDK), iCBCTfast, iCBCT

Feature Extraction & Analysis,

- 837 radiomic features extracted (original + wavelet-based) per 16 inserts
- Stability: ICC(1,1) [≥ 0.90 = **highly** stable] and CV [$< 5\%$ = **high** reproducibility]
- The Wilcoxon signed-rank tests (< 0.05)

Intraclass Correlation Coefficient ICC(1,1)

$$ICC(1,1) = \frac{MS_R - MS_W}{MS_R + (k-1)MS_W}$$

MS_R : mean square for Rows
 MS_M : mean square for residual sources of variance
 k : measurements

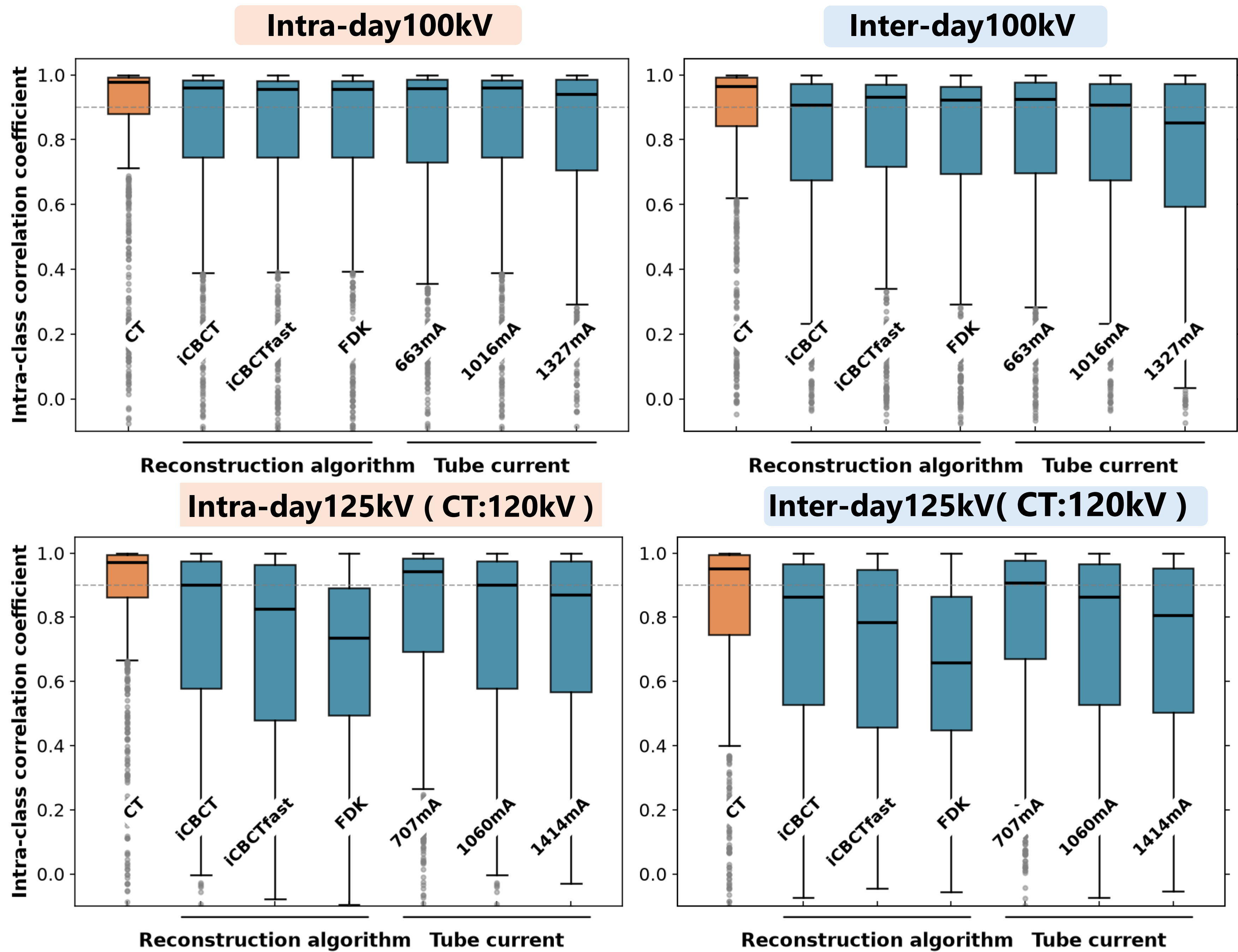
Coefficient of variation (CV)

$$COV = \frac{f_{SD}}{f_{mean}}$$

f_{SD} : standard deviation of each feature
 f_{mean} : mean of each feature

RESULTS

Intra- and Inter-day ICC Repeatability



CT showed **higher ICC** values than HS-CBCT for both repeatability measures, while median ICC and variability were **comparable** across **all HS-CBCT conditions**.

CT **outperformed** HS-CBCT in ICC for both repeatability measures. Among HS-CBCT conditions, **iCBCT** and **707 mA** showed the **highest** median ICC.

Summary of radiomic feature stability

Tube voltage	Modality / Condition	Tube current [mA]	Intra			Inter		
			ICC Median	ICC ≥ 0.9 (%)	CV Median (%)	ICC Median	ICC ≥ 0.9 (%)	CV Median (%)
100 kV	CT	-	0.98	72.8	3.05	0.96	68.0	3.93
	FDK	1016	0.96	62.2	2.67	0.92	53.5	4.69
	iCBCTfast	1016	0.96	61.8	2.77	0.93	56.2	4.47
	iCBCT	663	0.96	59.0	3.14	0.92	52.8	4.76
		1016	0.96	60.1	2.94	0.91	51.3	5.24
		1327	0.94	56.6	2.98	0.85	43.7	4.92
125 kV (CT:125kV)	CT	-	0.97	70.5	2.94	0.95	62.5	4.06
	FDK	1060	0.73	21.1	4.77	0.61	14.2	7.36
	iCBCTfast	1060	0.83	40.1	2.97	0.91	33.8	4.44
	iCBCT	707	0.94	56.0	2.91	0.91	51.7	4.30
		1060	0.90	50.1	3.27	0.86	45.2	4.97
		1414	0.87	46.5	2.44	0.81	38.1	4.01

Results are shown for intra-day and inter-day repeatability by modality and acquisition condition. All HS-CBCT conditions showed **significant differences** relative to CT.

DISCUSSION

- This is the **first study** to quantitatively investigate the intra-day and inter-day repeatability of radiomic features acquired with HS-CBCT.
- CT significantly **outperformed** HS-CBCT in both intra-day and inter-day reproducibility across **all tube voltages**.
- Although feature stability varied depending on imaging parameters, low tube current and iCBCT demonstrated **superior stability**, suggesting their potential **utility**.
- Rigorous feature pre-selection is **essential** for longitudinal delta-radiomics studies using HS-CBCT.

CONCLUSIONS

In this study, CT demonstrated significantly **higher ICC values** than HS-CBCT for both intra- and inter-day repeatability across **all acquisition conditions**. Among HS-CBCT settings, iCBCT at 125 kV showed intra-day stability comparable to that of CT, though inter-day reproducibility remained **inferior**.

REFERENCES

- Jha AK, Mithun S, Jaiswar V, et al. Repeatability and reproducibility study of radiomic features on a phantom and human cohort. Sci Rep. 2021
- Adachi T, Nakamura M, Iramina H, et al. Identification of reproducible radiomic features from on-board volumetric images: A multi-institutional phantom study. Med Phys. 2023