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Comparison of CT Number and Geometric Measurement Consistency of Dual-source vs. Single-source Spectral Imaging on a Photon-counting CT: a Phantom Study

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ABSTRACT

Dual-source photon-counting CT (DS-PCCT) enables fast FLASH acquisition combined with spectral imaging—capabilities not available in single-source PCCT (SS-PCCT). This phantom study evaluated whether DS-PCCT maintains quantitative accuracy by comparing CT number and geometric measurement consistency against SS-PCCT across three phantom sizes and a range of pitch values on a photon-counting CT system. Across 27 rod–image-type comparisons, linear mixed-effects models showed no statistically significant differences between DS- and SS-PCCT in 26 comparisons for either CT numbers or geometric measurements. DS-PCCT demonstrated CT number accuracy and geometric performance consistent with SS-PCCT, supporting its reliability for routine clinical use and establishing it as a robust platform for fast, accurate spectral imaging.

INTRODUCTION

Dual-source photon-counting CT (DS-PCCT) enables fast FLASH acquisition combined with spectral imaging—capabilities not available in single-source PCCT (SS-PCCT). This study evaluates whether DS-PCCT maintains quantitative accuracy by comparing CT number and geometric measurement consistency with SS-PCCT across multiple phantom sizes and scan parameters.

METHODS AND MATERIALS

Three cylindrical phantoms (20×20 cm, 33×26 cm, 40×30 cm) were scanned using a photon-counting CT system (NAEOTOM Alpha, Siemens). Seven large rods as inserts (28 mm diameter, iodine 0.5–20 mg/mL, solid-water, lung-equivalent) were analyzed for CT numbers, while three small iodine rods (2, 5, 10 mm) were used for geometric measurements. Scans followed a chest CTA protocol at 120 kV with IQ level of 90 and CTDIvol of 1.2, 3.2, and 5.2 mGy, respectively for each phantom. SS-PCCT used pitches of 0.8 and 1.5, and DS-PCCT used pitches of 1.5–3.2. Images were reconstructed with 2 mm slices, Bv40f kernel, iterative level 3, and spectral image types (55 keV virtual monoenergetic, virtual noncontrast, iodine maps). In each image, ROIs were placed in each large rod, and small-rod areas were quantified using adaptive thresholding.

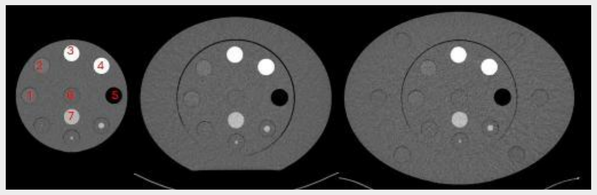

Figure 1. The three phantoms (small, medium, and large) used in the study are shown with the seven analyzed inserts labeled from 1 to 7: iodine 0.5, 1.0, 10, and 20 mg/mL; lung-equivalent (LN300); solid water; and iodine 5.0 mg/mL. The lower three inserts containing cores were not part of this study.

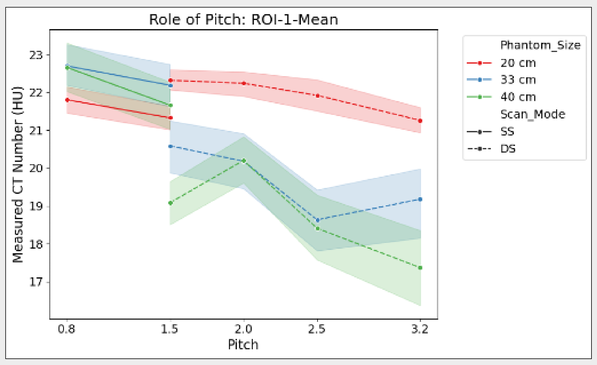

Figure 2(a) CT number, 0.5 mg/mL iodine rod

RESULTS

Across all rod–image-type combinations, linear mixed-effects models showed no statistically significant ($p>0.05$) differences between DS- and SS-PCCT for CT numbers or geometric measurements in 26 of 27 comparisons. Interactions between scan mode (DS vs. SS) and pitch were also not significant in most comparisons. Pitch had no statistically significant effect on area consistency and minor effects on some CT number measurements, with pitch-related slopes generally <5 HU.

Across image types, mean CT number errors were small—about -1.1 HU at 55 keV, 0.10 HU for virtual noncontrast, and -0.03 mg/mL for iodine-map images—confirming accurate quantification in both acquisition modes.
The largest differences were linked to phantom size and acquisition mode—most evident at the 40 cm phantom—while pitch had comparatively little effect. Where DS and SS differed, the gaps stayed within roughly a few HU, well below clinically meaningful thresholds.

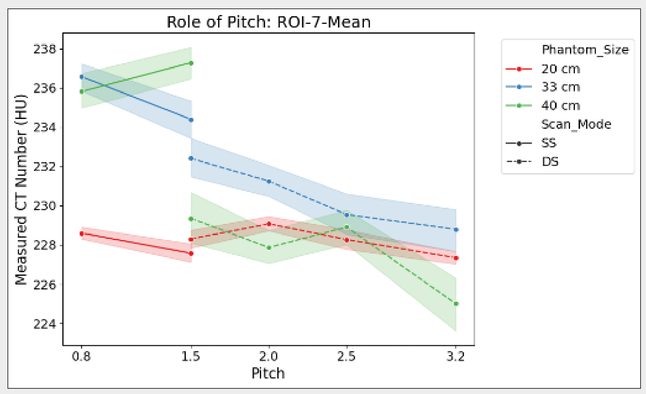

Figure 2(b) CT number, 5 mg/mL iodine rod

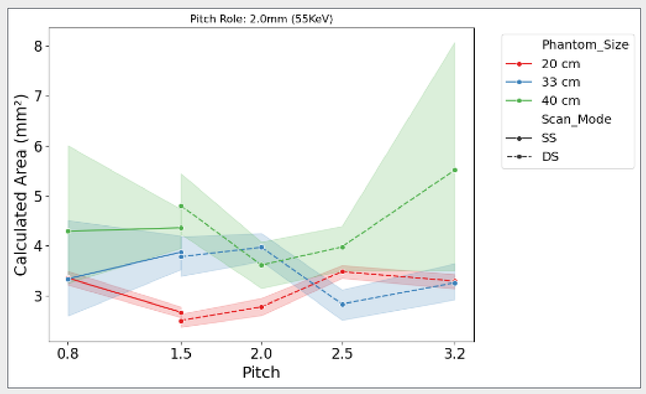

Figure 2(c) Area, 2 mm rod at 55 keV

Figure 2. Representative CT number and geometric measurements versus pitch. CT error (a, b) and measured rod area (c–e) are plotted for dual-source (DS) and single-source (SS) acquisitions across three phantom sizes (20, 33, 40 cm); shaded areas are 95% confidence intervals, and phantom size had the dominant effect on all measurements. (a, b) CT numbers showed a slight downward trend with pitch, but the slopes were small enough to be clinically irrelevant. (c–e) No clear trend was seen between area and pitch; the 2 mm area varied widely, especially for the 40 cm phantom, reflecting the difficulty of the task for large phantoms.

DISCUSSION

DS-PCCT resolves the historical trade-off between fast acquisition (FLASH mode) and spectral imaging. This study confirms that combining these capabilities does not compromise quantitative accuracy—critical for applications such as cardiac and pediatric imaging—and establishes DS-PCCT as a robust platform for fast, accurate spectral imaging.

CONCLUSIONS

DS-PCCT demonstrated consistency in CT number accuracy and geometric performance compared with SS-PCCT, supporting its reliability for routine clinical use.

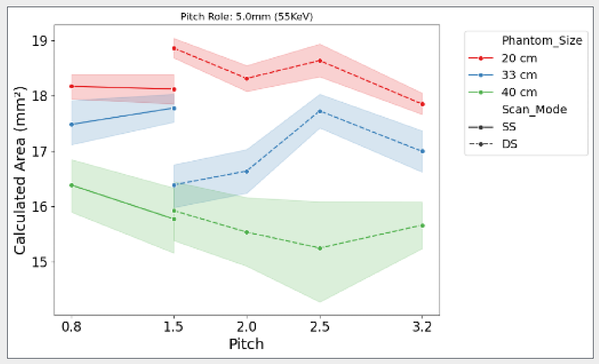

Figure 2(d) Area, 5 mm rod at 55 keV

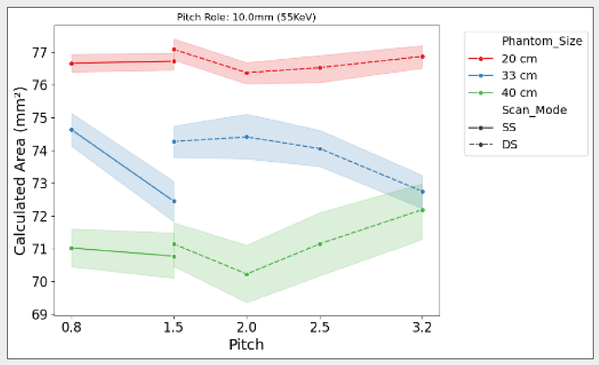

Figure 2(e) Area, 10 mm rod at 55 keV

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