2026 JULY 19–22 VANCOUVER, BC
JOINT AAPM | COMP MEETING

Impact of Tin Spectral Filtration in Renal Stone Imaging in Photon-Counting CT

Gerardo Garcia[1]; Andrew Primak[2], PhD; Wadih Karim[1]; and Grant Fong[1,†]
[1]Cleveland Clinic Foundation, Cleveland, OH; [2]Siemens Healthineers USA, Malvern, PA; [†]Senior Author

ABSTRACT

Purpose: Tin filtration has shown improved dose efficiencies in conventional CT for renal stone imaging. Photon-counting CT (PCCT) enables virtual monoenergetic image (VMI) reconstructions that can enhance stone conspicuity. This study evaluates potential dose-efficiency benefits of tin filtration with PCCT when renal stone imaging is performed using monoenergetic reconstructions.

Materials and Methods: A Mercury phantom was scanned on a PCCT system (NAEOTOM Alpha, Siemens Healthineers) to evaluate calcium contrast-to-noise ratio (CNR) as a function of phantom size. Ultra-high resolution acquisitions were performed at 120 kV (non-tin) and 100 kV with tin filtration (100Sn) at a fixed $CTDI_{vol}$. Images were reconstructed as 65 keV VMI and low-energy threshold (T3D) using medium- and high-resolution kernels (Br44 and Br64). Renal stone detectability was performed using a QRM phantom containing 1-, 3-, and 5-mm calcium stones. For 120 kV and 100Sn acquisitions, images were reconstructed using identical reconstruction settings. Scan dose was systematically varied to identify the minimum dose at which each stone size was detectable.

Results: Calcium CNR decreased with increasing phantom size for all conditions. At a given size, 100Sn VMI reduced calcium CNR relative to T3D, while 120 kV VMI increased CNR relative to T3D. For T3D reconstructions, 100Sn and 120 kV VMI demonstrated higher CNR than 100SN with 65 keV VMI for small to medium phantom sizes, with comparable trends at larger sizes. In the QRM phantom, when reconstructed with the higher-resolution Br64 kernel, 100Sn enabled visualization of 1-mm calcium stones, whereas corresponding non-tin reconstructions did not consistently demonstrate detectability at the same dose levels.

Conclusions: In PCCT, the dose-efficiency advantages of tin filtration in conventional renal stone imaging depend on the reconstruction strategy. Tin filtration degrades calcium CNR for VMI imaging while improving and preserving performance in total-energy reconstructions, particularly for higher-resolution tasks.

CONTACT

Gerardo Garcia / Grant Font
Cleveland Clinic Foundation
garciag19@ccf.org

Cleveland Clinic

INTRODUCTION

Background
Additional filtration like tin in CT imaging has historically been used to help improve dose optimization due to its filtration of lower energy photons in the X-ray beam[1]. PCCT enables VMI and has been shown to improve image quality in various applications such as in head and neck studies[2]. Combination of the effects of tin filtration along with PCCT VMI on dose savings and image quality improvements are currently not well understood.

Purpose
To evaluate the potential dose-efficiency benefits of using added tin filtration with PCCT during renal stone imaging using monoenergetic reconstructions.

METHODS AND MATERIALS

Scanning Parameters

- Quantum CT (PCCT) @ 120 kVp
- HiRes @ 120 kVp
- Quantum CT with Tin Filtration (PCCT) @ 100 kVp
- HiRes with Tin Filtration @ 100 kVp
- $CTDI_{vol}$ – 5 mGy
- Pitch – 0.8 mm

Image Reconstruction Parameters

- VMI reconstructed at 65 keV
- Low-energy Threshold (T3D)
- Kernels: Br44, Br46

Phantom

- Sun Nuclear Mercury 4.0 Phantom
- QRM Spectral CT Phantom

DISCUSSION AND CONCLUSIONS

Calcium CNR in PCCT decreased with increasing patient size, consistent with trends observed in conventional CT (Figure 1). Relative to the respective T3D reconstruction, VMI generally enhanced calcium CNR for non-tin acquisitions but degraded calcium CNR for tin-filtered acquisitions (Figure 2). In contrast, T3D reconstructions acquired with tin filtration demonstrated higher calcium CNR than non-tin T3D for small- to medium-sized patients, with no advantage observed for larger sizes (Figure 2). When dose was matched, non-tin VMI and tin T3D demonstrated comparable renal stone detectability for 1-mm stones, except that tin T3D demonstrated improved performance when higher-resolution reconstruction kernels were used (Figure 3).

REFERENCES

1. Bebbington, Natalie Anne et al. "CT radiation dose reduction with tin filter for localisation/characterisation level image quality in PET-CT: a phantom study." *EJNMMI physics* vol. 11,1 100. 25 Nov. 2024, doi:10.1186/s40658-024-00703-6
2. Farhadi, Faraz et al. "Virtual monoenergetic imaging in photon-counting CT of the head and neck." *Clinical imaging* vol. 102 (2023): 109-115. doi:10.1016/j.clinimag.2023.08.004

RESULTS

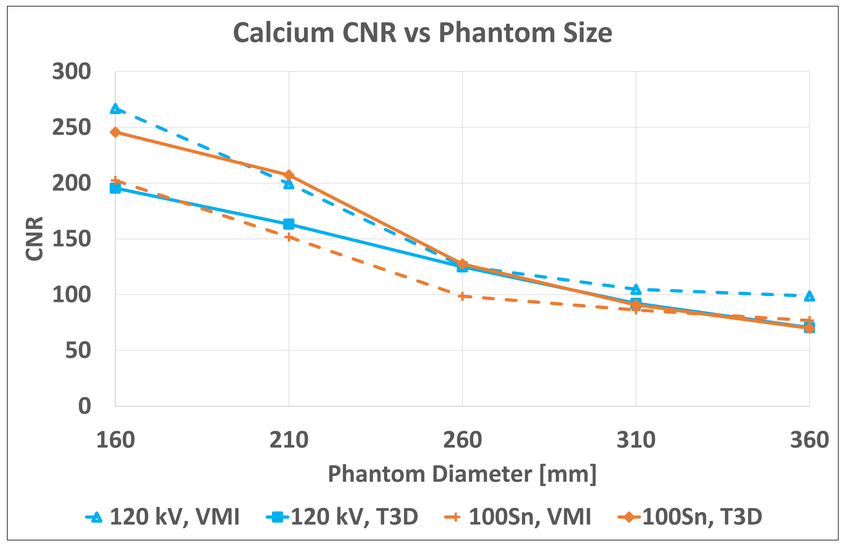

Figure 1: Calcium CNR vs Phantom Size

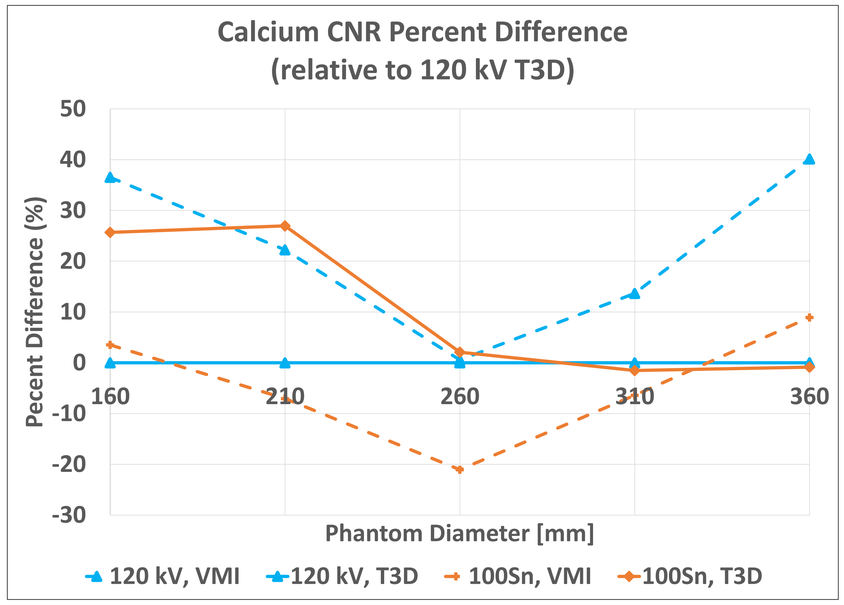

Figure 2: CNR Percent Difference Relative to 120 kV T3D

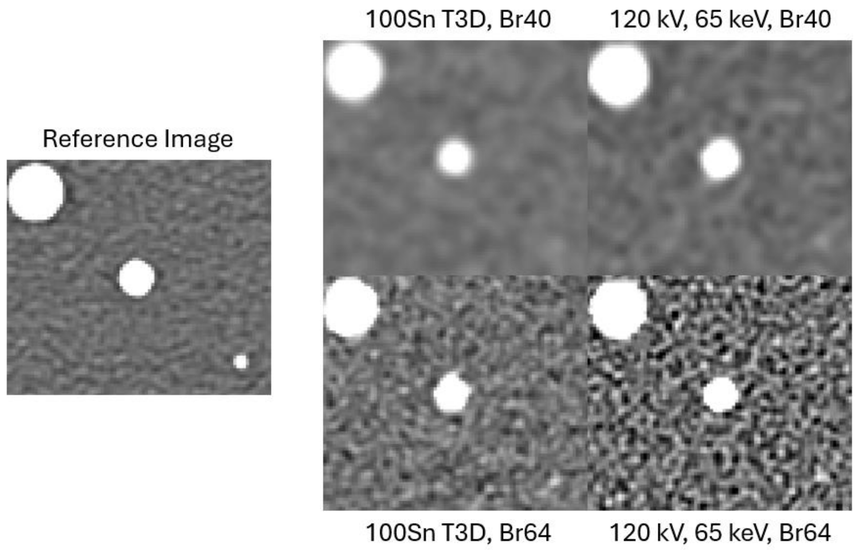

Figure 3: Calcium stones at 1-, 3-, and 5-mm imaged using 100Sn T3D and 120 kV VMI, at detectability threshold-dose level for 1-mm stone. Reconstruction at medium-sharp kernel (top row) degrades 1-mm stone detectability, while reconstruction at sharper-kernel (bottom row) enhances detectability for high-resolution calcium tasks.