Quantitative Evaluation of Reconstruction Methods for 180° Vs. 360° Acquisition Protocols In ^{99m}Tc-Sestamibi SPECT of Renal Tumors

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ABSTRACT

- Quantitative ^{99m}Tc -sestamibi SPECT/CT is routinely used to distinguish benign kidney tumors from renal cell carcinoma.
- Standard clinical acquisitions: 360° orbits
- Posterior clinical acquisitions: 180° orbits
  - ➢ Potential Benefits: Reduce scan time, patient discomfort, and maintain quantitative accuracy
- Goal: This study evaluates whether a 180° acquisition preserves linear quantitative relationships and quantitative consistency relative to 360° acquisitions across tumors and multiple organs.

INTRODUCTION

- SPECT/CT imaging using ^{99m}Tc -sestamibi can help differentiate benign/indolent tumors, like oncocytoma, from malignant renal cell carcinoma (RCC).
- The clinical standard protocol acquires projection data over 360° around patients, but 180° posterior scans closer to the kidneys can be done with the benefits of:

➢ **Decreasing scan time**

➢ **Reducing patient discomfort**

➢ **Maintaining quantitative diagnosis accuracy**

- **Objective:** Evaluate if 180° acquisitions provide comparable diagnostic and quantitative performance to 360° acquisitions for renal tumor characterization.

METHODS AND MATERIALS

Dataset: N = 50 patients with renal tumors imaged with ^{99m}Tc -sestamibi SPECT/CT

- 360° orbit with 120 views
- 180° orbit with 60 posterior views (extracted from the 360°)

Reconstruction Methods: Ordered-Subsets Expectation-Maximization (OS-EM)

- ➢ 8 iterations
- ➢ 10 subsets per iteration for 360°, 6 subsets per iteration for 180°

- Compensation for:
  - ➢Attenuation, Collimator-Detector response, and Scatter (ADS)
  - ➢ Attenuation and Collimator-Detector response (AD)
  - ➢ Attenuation only (A)
  - ➢ No compensation (N)

Metrics:

- Tumor cutoff threshold classification of "hot" or "cold" with a relative uptake (RU) between mean values of a tumor (manual segmentation) or organ (MONAI segmentation) and healthy kidney (MONAI segmentation)

$$RU = \frac{\textit{Mean of Organ or Tumor}}{\textit{Mean of Healthy Kidney}}$$

- Diagnostic Classification Threshold (Tumors): 0.68
- Linear Regression Metrics (Tumors and Organs):
  - ➢ R^2, slope, offset
- Bland-Altman Analysis (Tumors and Organs)

RESULTS

- Across organs and tumors, compensated reconstructions (ADS/AD/A) generally show stronger linearity and reduced bias relative to uncompensated reconstruction (N).
- Bland-Altman compensation (ADS/AD/A) results show differences centered around zero with tight clustering compared to N.

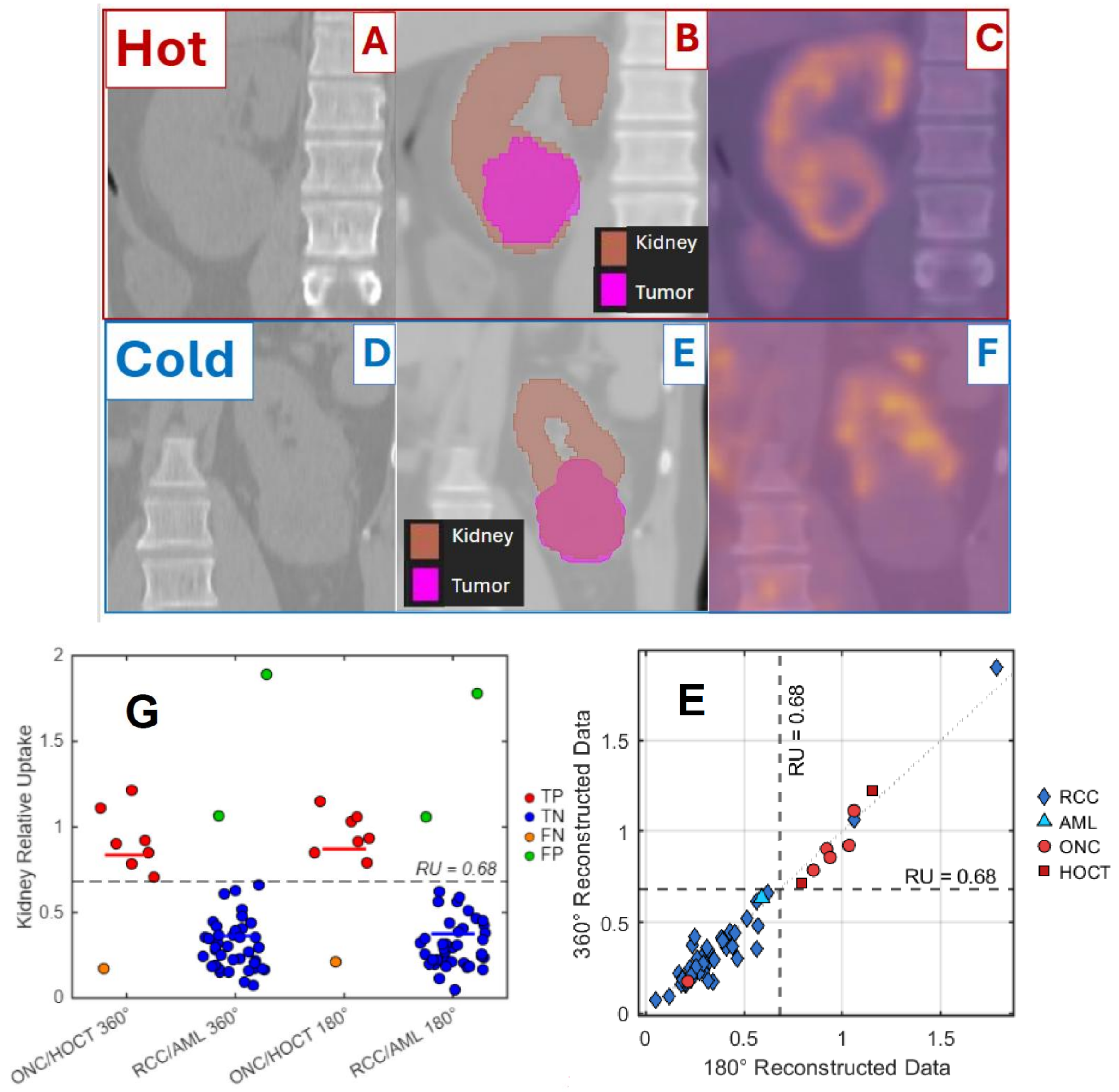

Figure 1. (A) CT "hot" tumor and (D) CT "cold" tumor with overlayed manual tumor segmentation and MONAI kidney segmentation for the same (B) "hot" tumor and (E) "cold tumor. ADS compensated SPECT/CT reconstruction results for the (C) "hot" tumor and (F) "cold" tumor (G) RU data distribution with difference diseases, (E) Linear fit of Tumor Data

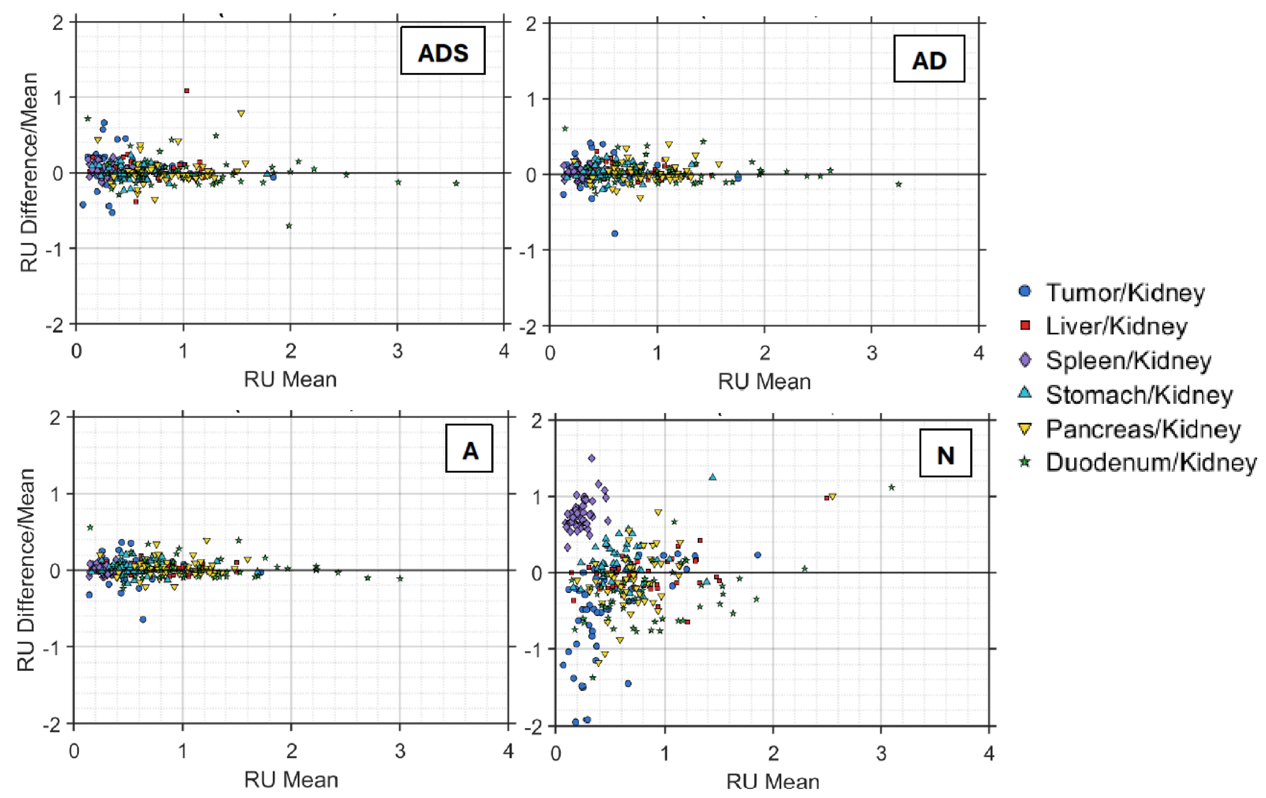

Figure 2. Plots for the mean 0.5*(180°+ 360°) vs. difference over mean (180° - 360°)/0.5*(180°+ 360°) of different organ values for different reconstruction methods

DISCUSSION

- With compensations, posterior 180° and 360° RU ratios had strong linear agreement across organs and tumors.
- The AD and A compensation methods had the best linear results. Scatter compensation could add nonlinear effects.
- The ADS and AD results had the largest diagnostic separation between high and low uptake values.

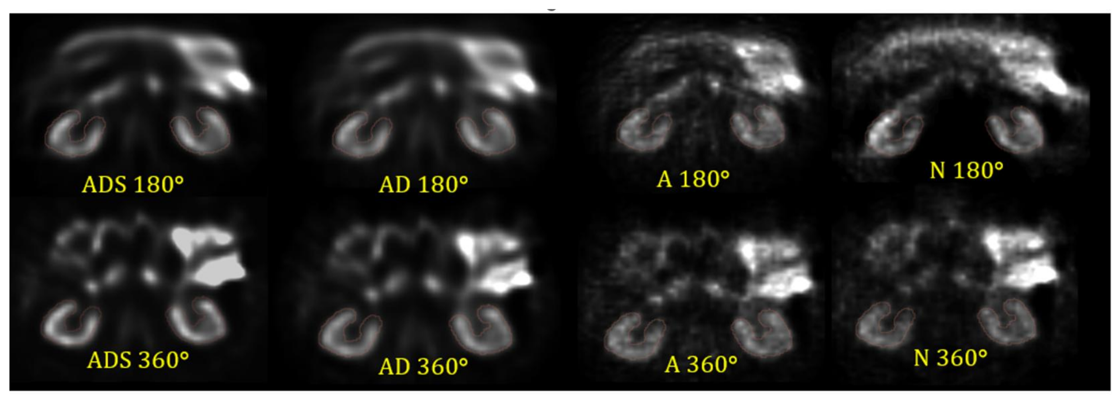

Figure 3. Examples of SPECT images reconstructed with different compensation methods (ADS, AD, A, N) and projection data (180° and 360°).

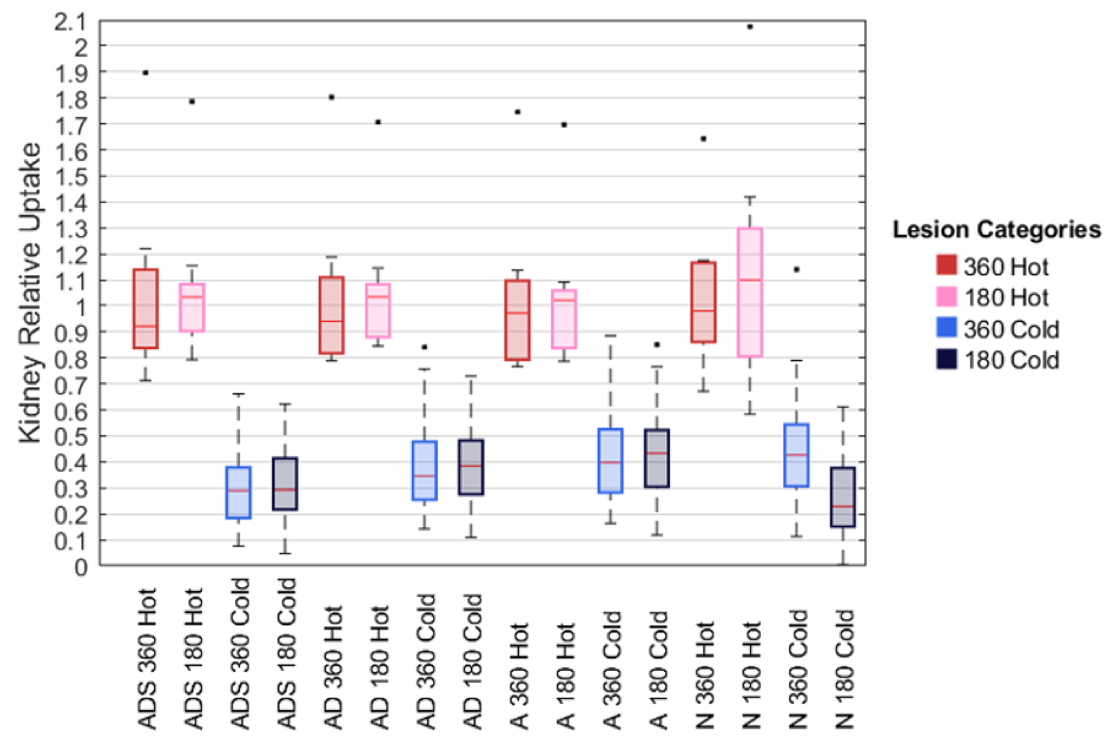

Figure 4. Box-and-whisker plot of RU between tumor and kidney for ADS, AD, A, and N OS-EM reconstruction for the 360 Hot, 180 Hot, 360 Cold, and 180 Cold dataset.

CONCLUSIONS

- Reconstruction compensation improves linearity, Bland-Altman, and high and low uptake tumor separation results.
- AD and A compensation appear to have better linearity results for some organs compared to ADS, while ADS and AD compensation have better separation between high and low uptake tumors.
- Further analysis of compensation methods is needed to prove determine the best imaging protocol.

REFERENCES

[1] M. A. Gorin, et al, Nature Reviews Urology, vol. 12, no. 8, pp. 445–450, 2015.

[2] C. R. Divgi et al., Journal of Clinical Oncology, vol. 31, no. 2, pp. 187–194, 2013.

[3] M. A. Gorin et al., European Urology, vol. 69, no. 3, pp. 413–416, 2016.

[4] S. P. Rowe et al., Clinical Nuclear Medicine, vol. 40, no. 4, pp. 309–313, 2015.

[5] K. M. Jones et al., Annals of Nuclear Medicine, vol. 32, no. 2, pp. 87–93, 2017.

[6] Y. Du, et al., Medical Physics, vol. 34, no. 9, pp. 3530–3543, 2007.

[7] S. P. Rowe et al., Molecular Imaging and Biology, vol. 26, no. 5, pp. 768–773, 2024.

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Table 1. Linear Regression Metrics (R^2, slope, offset) for organ-to-kidney ratios across reconstruction methods

	ADS			AD			A			N		
Organ Ratio	R^2	Offset	Slope	R^2	Offset	Slope	R^2	Offset	Slope	R^2	Offset	Slope
Tumor/Kidney	**0.96**	0.040	0.95	**0.91**	0.047	0.92	**0.92**	0.032	0.94	0.71	0.186	1.11
Liver/Kidney	0.72	0.081	0.97	**0.96**	0.024	1.00	**0.97**	0.005	0.98	0.46	0.053	0.79
Spleen/Kidney	**0.96**	0.000	1.03	**0.96**	0.005	1.04	**0.96**	0.002	1.02	0.58	0.029	2.09
Stomach/Kidney	**0.97**	0.021	0.94	**0.96**	0.023	1.00	**0.96**	0.031	0.98	0.29	0.225	0.79
Pancreas/Kidney	0.71	0.035	0.99	0.87	0.015	1.01	0.88	0.031	1.00	0.32	0.194	1.27
Duodenum/Kidney	0.89	0.152	0.84	**0.95**	0.088	0.94	**0.95**	0.094	0.93	0.36	0.028	0.46

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