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Determination of Optimal iCBCT Reconstruction Parameters for a New Imaging System on a C-Arm Linac

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ABSTRACT

Purpose: To enhance image quality for image-guided radiotherapy (IGRT) by determining the most optimal combination of filter and noise suppression level used in iterative reconstruction of cone beam CT data (iCBCT) acquired with a new imaging panel on a C-arm linac.

Methods: Raw CBCT data from various patient scans was reconstructed with different combinations of filters (Standard, Smooth, Sharp) and noise suppression levels (Very Low, Medium, Very High). Two surveys were designed: scans that used 'head' parameters (100 kV, 149 mAs) and scans that used 'pelvis' parameters (125 kV, 1093 mAs). Each survey consisted of 20 separate side-by-side comparisons of the different reconstruction combinations. In each comparison, reconstructed images were not labeled and were presented in no particular order. 11 physicists and 4 physicians from our institution participated in this survey, selecting their preferred image quality in each of the 40 comparisons. A 95% two-way cluster bootstrap confidence interval (CI) is used to determine the preferred iCBCT image reconstruction parameters. Catphan scans were used to evaluate spatial resolution and low contrast resolvability using the same scan parameters and iCBCT reconstruction combinations.

Results: The preferred filter for both scan parameters was Sharp, with a CI of [52.6%,77.4%]. A Catphan scan reconstructed with each filter resulted in spatial resolutions of 6, 7 and 8 lp/cm respectively. The CI for Medium noise suppression preference was [35.0%,67.2%] The spatial resolution decreased by 1 lp/cm for each filter when noise suppression increased from medium to high.

Conclusion: To provide the most preferable image quality for IGRT, CBCTs acquired with our new C-arm linac imaging panel should use a Sharp filter with Medium noise suppression for iCBCT reconstruction. This is supported through CI calculation from an intensive survey provided to staff at our clinic, and agrees with spatial resolution and low contrast resolvability Catphan analysis.

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INTRODUCTION

Cone-beam computed tomography (CBCT) image quality is influenced by reconstruction settings, including noise suppression and reconstruction filter. Although multiple iterative CBCT (iCBCT) reconstruction options may be available on modern linear accelerators, default clinical settings may not provide the preferred balance between noise reduction, spatial resolution, and anatomical visualization.
In this study, radiation oncologists and medical physicists at a single clinic completed a survey comparing identical CBCT projection data reconstructed with different iCBCT parameter combinations available through service mode. Because each comparison used the same underlying acquisition, differences in preference were attributed primarily to the reconstruction settings. Bootstrap confidence intervals were used to determine whether observed preferences between reconstructions were statistically significant and to identify the most consistently favored parameter combination.
The preferred reconstruction was then qualitatively compared with the default clinical reconstruction using commercial Catphan CBCT analysis software. This approach combined clinical observer preference with phantom-based image-quality assessment to evaluate whether subjective improvements corresponded with measurable changes in image quality

METHODS AND MATERIALS

Raw CBCT data from various patient scans was reconstructed with different combinations of filters (Standard, Smooth, Sharp) and noise suppression levels (Very Low, Medium, Very High). Two surveys were designed: scans that used 'head' parameters (100 kV, 149 mAs) and scans that used 'pelvis' parameters (125 kV, 1093 mAs). Each survey consisted of 20 separate side-by-side comparisons of the different reconstruction combinations. In each comparison, reconstructed images were not labeled and were presented in no particular order.

Survey participants included 11 physicists and 4 physicians from our institution, selecting their preferred image quality in each of the 40 comparisons. A 95% two-way cluster bootstrap confidence interval (CI) is used to determine the preferred iCBCT image reconstruction parameters.

Commercial software was used to quantitatively evaluate Catphan scans for spatial resolution and low contrast resolvability using the same scan parameters and iCBCT reconstruction combinations.

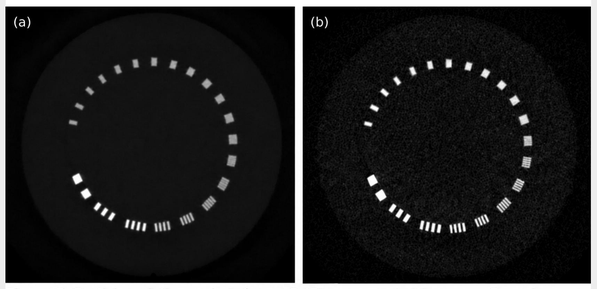

Figure 3: Spatial resolution analysis from a CatPhan scanned with our new C-arm linac imaging panel using iCBCT reconstruction and (a) smooth filter with high noise suppression, (b) sharp filter with low noise suppression.

RESULTS

Accounting for between-question variability and correlation of answers within respondents, we are 95% confident that the true proportion of responses selecting sharp filter with medium noise suppression lies between 52.6% and 77.4% [0.526,0.774].
The preferred combination of sharp filter with medium noise suppression was deemed site independent, as brain and head & neck cases show 95% confidence between 49.4% and 81.7% [0.494,0.817], and abdominal and pelvis cases show 95% confidence between 49.0% and 80.0% [0.490,0.800]. Cross comparisons of the 9 reconstruction methods are shown in Figures 1 and 2 below.
A Catphan scan reconstructed with each filter resulted in spatial resolutions of 6, 8 and 8 lp/cm for smooth, standard, and sharp respectively. The CI for Medium noise suppression preference was [35.0%,67.2%] The spatial resolution decreased by 1 lp/cm for each filter when noise suppression increased from medium to high. These extremes of reconstruction parameter effects for spatial resolution can be seen in Figure 3.

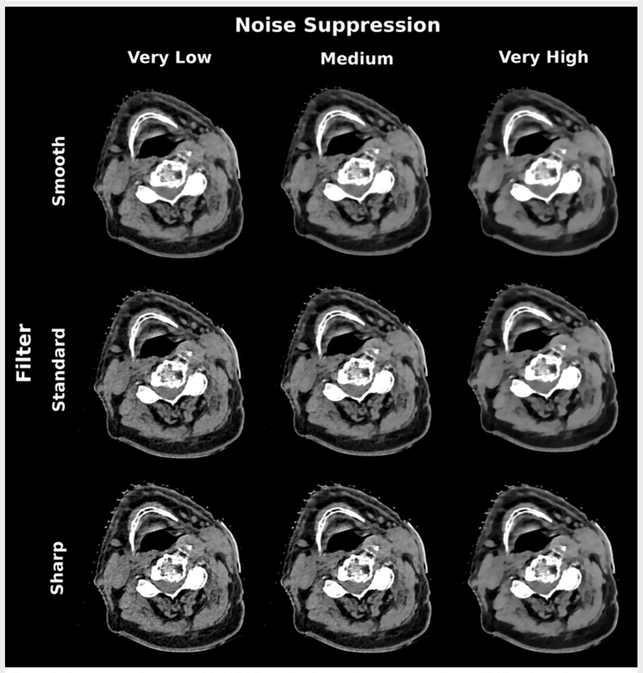

Figure 1: Comparison of each possible iCBCT combination, each reconstructed from a CBCT performed on a head and neck patient with our new C-arm linac imaging panel.

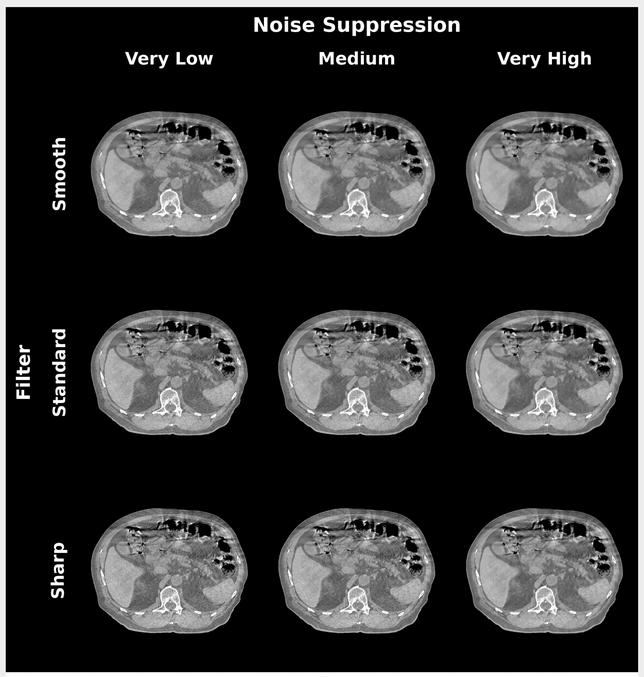

Figure 2: Comparison of each possible iCBCT combination, each reconstructed from a CBCT performed on an abdominal patient with our new C-arm linac imaging panel.

DISCUSSION

This study demonstrates a practical method for optimizing iCBCT reconstruction settings by combining clinical observer preference with objective phantom-based image-quality assessment. The survey identified the sharp reconstruction filter with medium noise suppression as the preferred setting among physicians and physicists in our clinic. Notably, commercial Catphan analysis showed image-quality metrics comparable to those obtained with the default reconstruction parameters. This suggests that the preferred reconstruction may improve perceived anatomical visualization without producing a measurable degradation in standard quantitative image-quality characteristics.

A useful aspect of this approach is that it evaluates reconstruction settings using identical underlying CBCT data, thereby isolating the effect of reconstruction parameters from differences in patient positioning or acquisition. The potential novelty lies in incorporating multidisciplinary clinical preference into the selection of service-mode iCBCT parameters rather than relying exclusively on vendor defaults or phantom measurements. These findings support institution-specific optimization of CBCT reconstruction protocols, while also emphasizing that subjective improvements may not always be fully captured by conventional phantom-based metrics.

CONCLUSIONS

A clinic-based observer survey identified the sharp reconstruction filter with medium noise suppression as the preferred iCBCT setting across multiple anatomical sites, including the abdomen and head and neck. Commercial Catphan analysis showed image-quality metrics similar to those obtained with the default reconstruction parameters, suggesting that the preferred setting improved perceived image appearance without compromising standard quantitative performance. These findings support combining clinical observer preference with phantom-based assessment when optimizing reconstruction protocols. Because conventional image-quality metrics may not fully capture differences in anatomical visualization or clinical usability, input from both radiation oncologists and medical physicists provides valuable complementary information. Institution-specific evaluation may therefore help establish clinically preferred iCBCT protocols while maintaining acceptable quantitative image quality.

REFERENCES

1. Gardner SJ, Mao W, Liu C, et al. Improvements in CBCT image quality using a novel iterative reconstruction algorithm: A clinical evaluation. *Adv Radiat Oncol.* 2019;4(2):390–400. doi: 10.1016/j.adro.2018.12.003
2. Arsenault T, Arrue J, Gregg K, et al. Characterization of a prototype rapid kilovoltage x-ray image guidance system designed for a linear accelerator radiation therapy unit. *J Appl Clin Med Phys.* 2025;26(5):e70060. doi: 10.1002/acm2.70060