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Evaluation of Z-axis resolution for axial and helical scanning modes on MDCT

Abstract
Philips CT Clinical Science • Philips Healthcare

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Abstract

CT Big Bore
4D, cine axial, helical, I
axis

Background
Cine axial and low pitch helical are two scanning modes commonly used to acquire 4D-CT image volumes. This study evaluated the Z-axis resolution of these two scanning modes on a 16-slice multi-detector CT (MDCT). Z-axis resolution was defined as the full-width at half maximum (FWHM) of the slice sensitivity profile (SSP).

Similar work has been previously published in the literature[1]. These studies only measured SSP for a well centered phantom in both the scan field and within the detector rings. This study explores the dependency of SSP on distance from scan field center and center detector ring for MDCT.

Materials and methods

Experimental Setup:
The CT-SSP Phantom (Model 76-412 from Fluke Biomedical, Solon, Ohio) was used. It contains an acrylic ball bearing (BB) embedded in low density foam. All scans were performed on a Philips CT Big Bore scanner. All scans were performed using 16 x 1.5 mm collimation and standard resolution. For helical scans, the slices were reconstructed with a 0.2 mm (lowest allowable) increment. For axial mode, three consecutive scans were performed with a 0.5 mm offset between them.

Variables:
The position of the BB relative to the edge detector ring was varied. This was effected by adjusting the start couch position so that the slice with the BB was positioned in the scan plane of different detector rings. The distance from the center of the gantry scan field was varied by raising or lowering the couch. For helical scanning the pitch was varied (0.04 - 0.2).

Analysis:
A zoomed reconstructed field of view centered on the BB was used. A circular ROI was drawn around the BB with a 2 mm margin. This ROI was then propagated to all slices. The highest CT number within the ROI was recorded (see Figure 1) and plotted vs. the slice location in Cartesian coordinates. The FWHM of the SSP plot was used to estimate the Z-axis resolution. All plotted values were scaled and biased such that 0.0 and 1.0 corresponded to the lowest and highest amplitude respectively as shown in Figure 3.

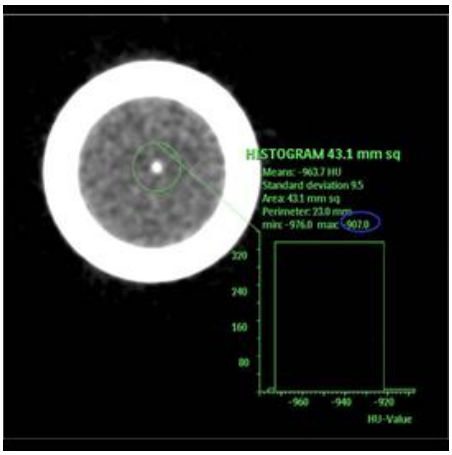


Figure 1
Highest CT number recorded for each slice

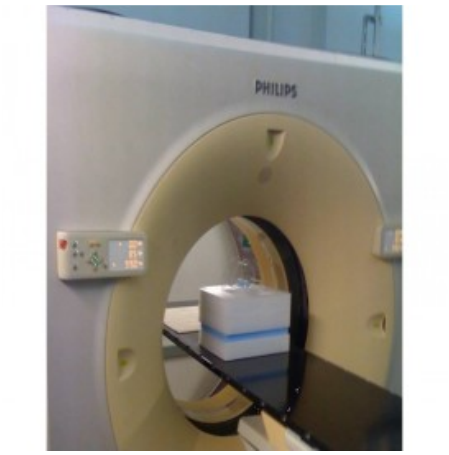


Figure 2
Experimental setup on the Brilliance Big Bore CT

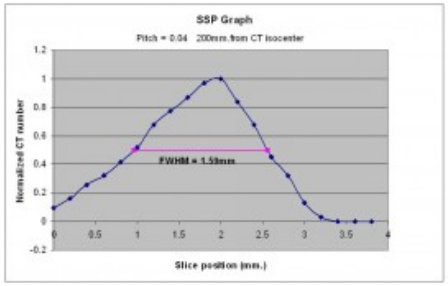


Figure 3
SSP plot with FWHM shown in purple

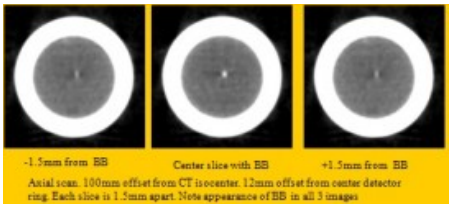


Figure 4a
Axial scan. 100 mm offset from CT isocenter. 12 mm offset from center detector ring. Each slice is 1.5 mm apart. Note the appearance of BB in all 3 images.

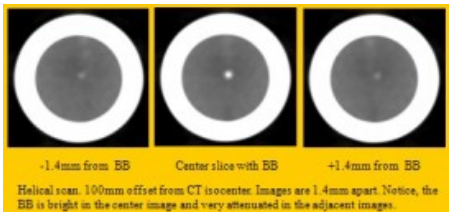


Figure 4b
Helical scan. 100 mm offset from CT isocenter. Images are 1.4 mm apart. Notice the BB is bright in the center image and very attenuated in the adjacent images.

Results

Centered:
With the phantom centered in the scan field, the axial scan mode had better z-axis resolution (1.46 mm avg.) in comparison with the helical mode (1.76 mm avg.). For helical mode, the z-axis resolution had some correlation with lower pitch. At the lowest pitch (0.04), it (1.40mm) was comparable to axial mode. At the highest pitch evaluated (0.2), the z-axis resolution did not exceed the reported slice thickness (2 mm) on the scanner by more than 10%.

Off-center:
In this case, the z-axis resolution for axial mode was severely degraded reaching almost 7 mm in the worst case (200 mm offset from CT isocenter). This was also very dependent on the slice location relative to the center ring. (This has been noted previously in the literature.)[2] For slices near to the edge, significant slice widening was measured even at locations 75 mm from CT isocenter. (see Figure 5) For helical mode, distance from scan center had a negligible impact. The effective slice

thickness had minor variance and was independent of offset from the CT isocenter. (see Figure 6) Note, the spiral scan with lowest pitch (0.04) did not exceeded a 1.8 mm SSP FWHM at all locations. This result is contrary to previously reported results on another vendor's scanner[1]. This discrepancy could be due to the different scanner geometry and/or helical reconstruction algorithms.

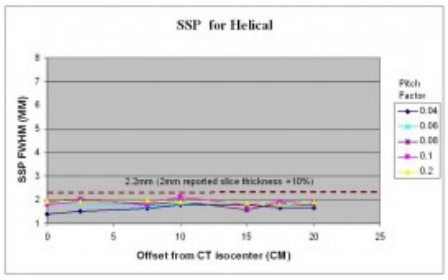


Figure 5

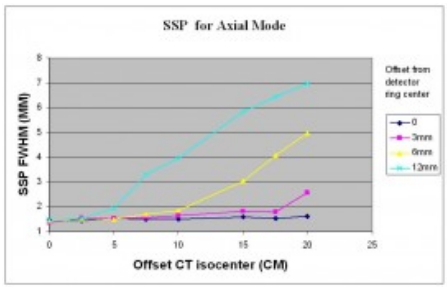


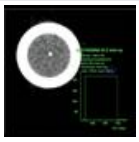
Figure 6

Conclusions

- Although axial mode scanning for 4D-CT can have slightly better z-resolution near the center of the scan field, this resolution can degrade significantly for pixels near the periphery of the imaging area and for slices not centered in the detector rings. Conversely, helical scanning can maintain a uniform effective slice thickness across the entire scanned field of view. For example, for a 0.04 pitch the thickness varied between 1.4 mm and 1.8 mm.
- The very low pitches (0.04 - 0.08) that are required for some 4D-CT studies do not have any measurable slice broadening effect and their SSP FWHM is comparable to well centered axial slices.

References

1. T. Pan. *Comparison of helical and cine acquisitions for 4D-CT imaging with multislice CT.* Med. Phys. 32, 627-634, 2005.
2. J. Hsieh. *Investigation of the slice sensitivity profile for step-and-shoot mode multi-slice computed tomography.* Med. Phys. 28, 491-500, 2001.



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This abstract from a presentation given at the 51st annual meeting at AAPM by Paul Klahr (Philips Healthcare) evaluates the Z-axis resolution of cine axial and low pitch helical scanning modes on a 16-slice MDCT.

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