Is measurement of $CTDI_{vol}$ with a helical scan an acceptable alternative to the standard single-slice methodology?

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Introduction

The standard method of measuring $CTDI_{vol}$, and the only method accepted by the ACR, requires using a single axial scan over a 100-mm pencil chamber.[1, 2] Measuring the $CTDI_{vol}$ from a clinical helical protocol requires "converting" it to an axial protocol, which may lead to problems matching collimation (nxT) values and bowtie filter; consequently, the tested protocol may not be a good substitute to the clinical protocol. Additionally, some nuclear hybrid units are incapable of acquiring axial scans without entering service mode. The purpose of this study was to determine whether $CTDI_{vol}$ can be accurately measured with a helical scan.

Methods

A total of 43 helical protocols from 15 CT scanners, representing all major manufacturers, were included in this study. First, the standard axial $CTDI_{vol}$ was measured using the methodology and equations required by the ACR.[2] A second helical measurement was acquired as follows:

- A topogram of the phantom with pencil chamber inserted was acquired.
- The clinical protocol was selected (unmodified except for setting a manual mA) and the scan range set equal to the active length of the chamber visible on the topogram (Figure 1).

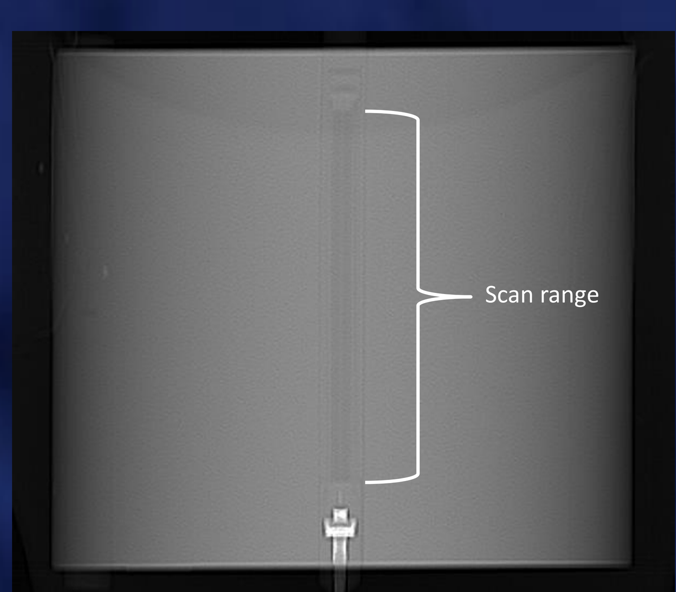

Figure 1. Topogram of the CTDI phantom with pencil chamber inserted. The air volume of the chamber is used to set the scan range.

- $CTDI_{vol}$ was calculated from the average of 3 measurements in the center phantom hole and 3 measurements in the 12:00 peripheral hole using:

$$CTDI_{100}(mGy) = 0.0087 \times X(mR)$$

$$CTDI_{vol}(mGy) = 0.333 \times CTDI_{100}^{center} + 0.667 \times CTDI_{100}^{peripheral}$$

Results

The differences between the axial measurements, helical measurements, and scanner-displayed values are summarized in Table 1. It was not possible to match collimation between the axial and helical acquisition modes in 10 of 43 protocols; the correlation between the helical $CTDI_{vol}$ and the axial $CTDI_{vol}$ was $R^2=0.98$ across all protocols and $R^2=0.99$ when restricted to protocols with matched collimation (Figure 2). A Bland-Altman graph shows excellent agreement between the measurement methods when collimation is matched; a few outliers occur when collimation is unmatched (Figure 3).

Protocol	Diff. between axial and displayed CTDI (mGy)*	Diff. between helical and displayed CTDI (mGy)*	Diff. between helical and axial CTDI (mGy)**
Adult head	-1.6 (-7.5, 5.1)	-3.9 (-9.1, -2.0)	0.4 (-2.0, 3.9)
Adult abdomen	-0.8 (-3.2, 0.6)	-0.1 (-3.0, 2.0)	0.7 (0.3, 1.4)
Pediatric head	-0.9 (-4.5, 5.1)	-2.2 (-4.4, 0.4)	0.4 (-0.5, 1.7)
Pediatric abdomen	-0.4 (-2.3, 3.0)	-0.2 (-1.2, 0.3)	0.0 (-2.9, 1.0)
All Protocols	-0.9 (-7.5, 5.1)	-1.6 (-9.1, 2.0)	0.4 (-2.9, 3.9)

Table 1. Average (max, min) differences in mGy between axial measurements, helical measurements, and displayed values. *Calculated using all protocols **Calculated using only protocols with matched collimation

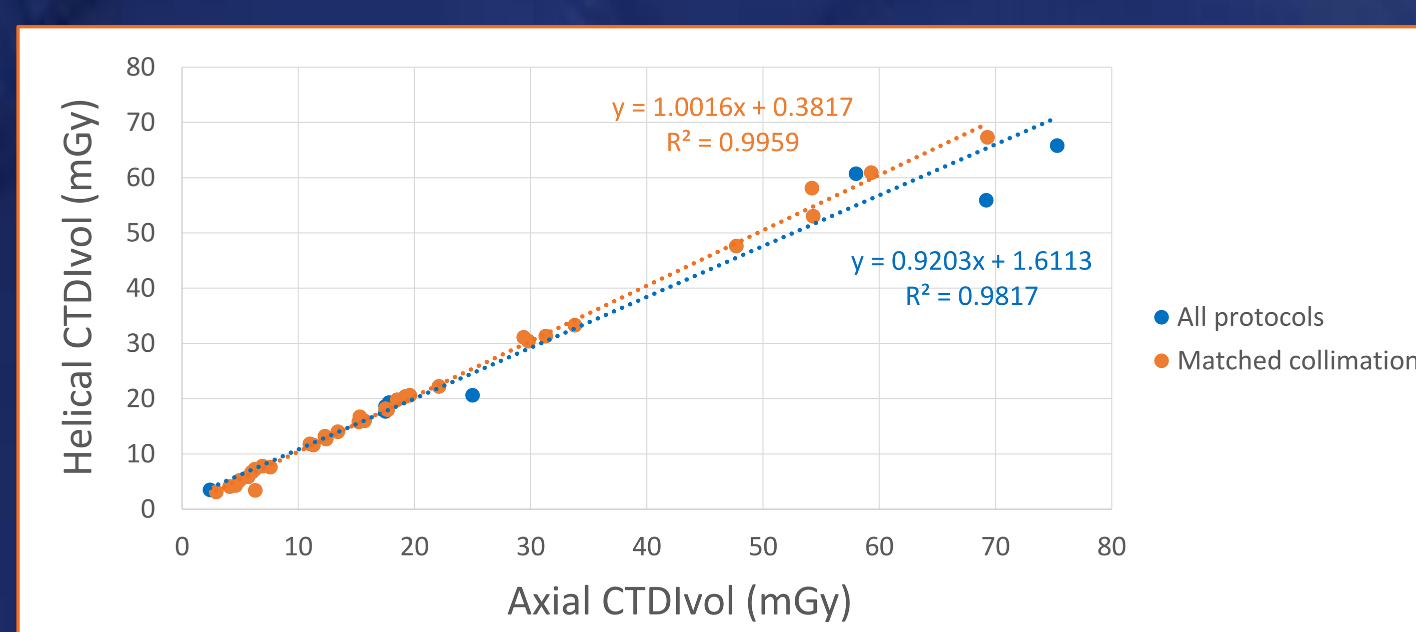

Figure 2. Correlation between axial and helical $CTDI_{vol}$ values.

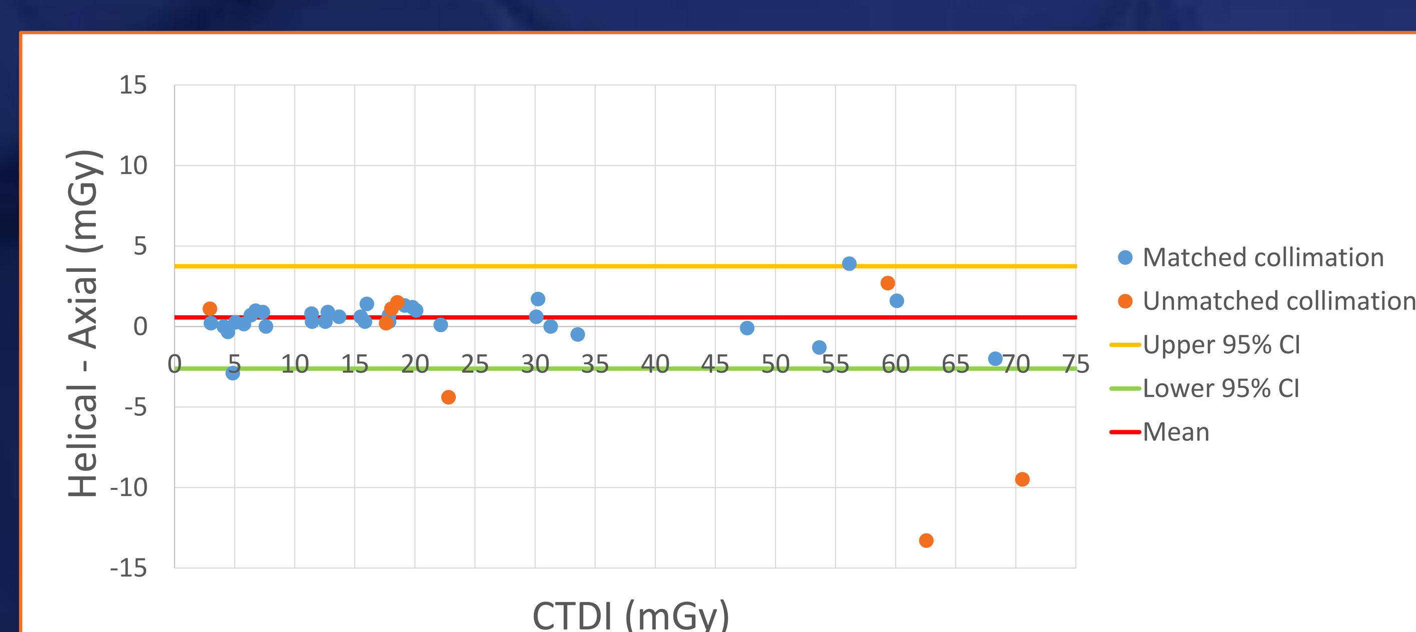

Figure 3. Bland-Altman plot showing differences between the axial and helical measurement methods.

Results

Figure 4 compares the scanner-displayed $CTDI_{vol}$ to the axial and helical measurements for the adult abdomen protocol (graphs for other protocols were similar). The helical scan agreed better with the scanner display in 70% of all protocols tested, without apparent manufacturer dependence. Two large discrepancies between the axial measurement and displayed $CTDI_{vol}$ (-43% and 90%) were noted in the pediatric abdomen protocol; no disagreements of greater than 20% were noted with the helical measurements on any protocol.

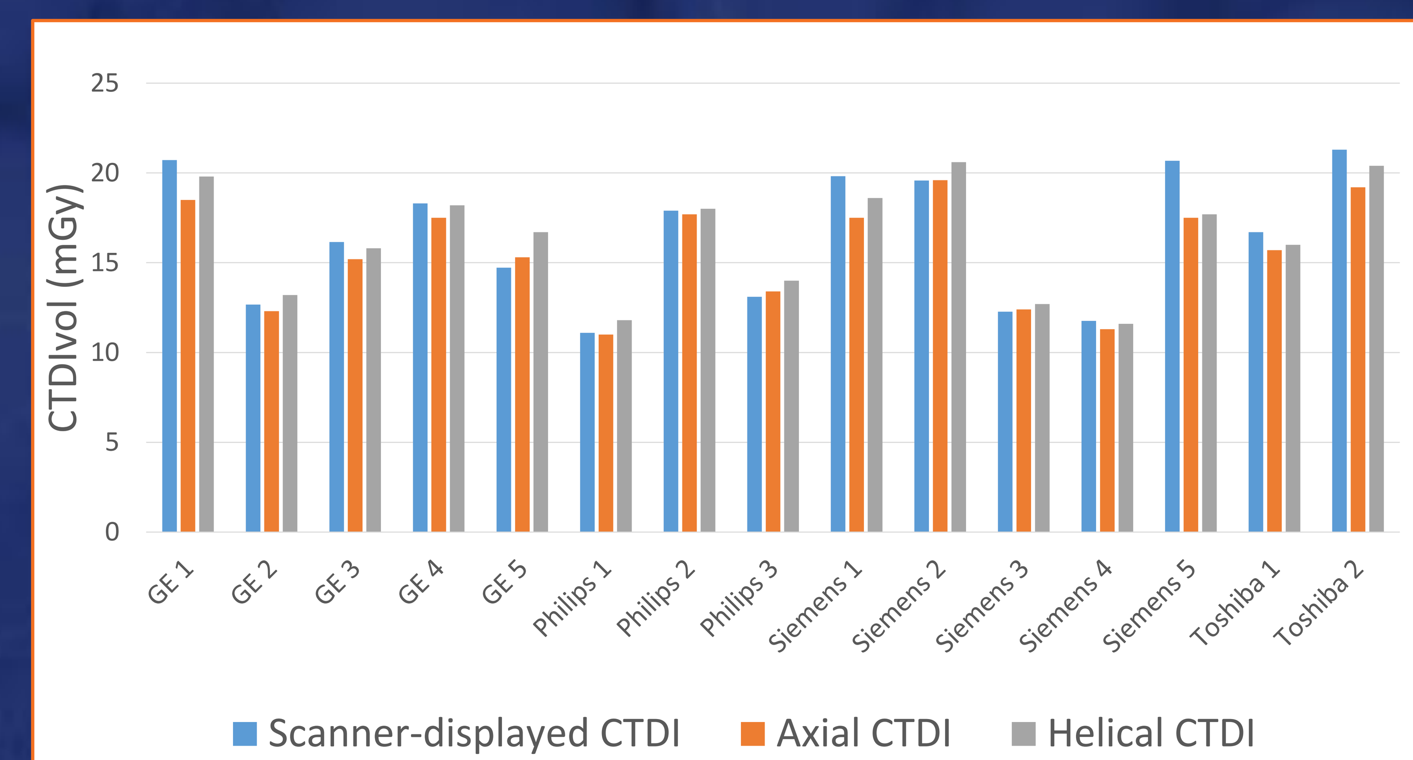

Figure 4. $CTDI_{vol}$ values for the adult abdomen protocol .

Conclusions

There was excellent agreement between the two measurement methods and to the displayed $CTDI_{vol}$. The helical measurement method can be accomplished more easily than the axial method on many scanners and is a reasonable testing method for QC purposes.

References

1. AAPM Report No. 96: The Measurement, Reporting, and Management of Radiation Dose in CT. College Park, MD: American Association of Physicists in Medicine, 2007.

2. American College of Radiology CT Accreditation Program Testing Instructions. Rev. 10/10/18. American College of Radiology; 2018.

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