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Technical Notes

Temporal resolution measurement of 128-slice dual source and 320-row area detector computed tomography scanners in helical acquisition mode using the impulse method

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ABSTRACT

Purpose: To analyse the temporal resolution (TR) of modern computed tomography (CT) scanners using the impulse method, and assess the actual maximum TR at respective helical acquisition modes.
Methods: To assess the actual TR of helical acquisition modes of a 128-slice dual source CT (DSCT) scanner and a 320-row area detector CT (ADCT) scanner, we assessed the TRs of various acquisition combinations of a pitch factor (P) and gantry rotation time (R).
Results: The TR of the helical acquisition modes for the 128-slice DSCT scanner continuously improved with a shorter gantry rotation time and greater pitch factor. However, for the 320-row ADCT scanner, the TR with a pitch factor of <1.0 was almost equal to the gantry rotation time, whereas with pitch factor of >1.0, it was approximately one half of the gantry rotation time. The maximum TR values of single- and dual-source helical acquisition modes for the 128-slice DSCT scanner were 0.138 (R/P = 0.285/1.5) and 0.074 s (R/P = 0.285/3.2), and the maximum TR values of the 64 × 0.5- and 160 × 0.5-mm detector configurations of the helical acquisition modes for the 320-row ADCT scanner were 0.120 (R/P = 0.275/1.375) and 0.195 s (R/P = 0.3/0.6), respectively.
Conclusion: Because the TR of a CT scanner is not accurately depicted in the specifications of the individual scanner, appropriate acquisition conditions should be determined based on the actual TR measurement.

Introduction

The temporal resolution (TR) of computed tomography (CT) is an index of a temporal element in a slice image that represents the temporal extent of the contribution of projection data in a reconstructed image. Thus, the TR in the non-helical acquisition (step-and-shoot acquisition) mode with complete projection data per one gantry rotation is equal to the gantry rotation time [1]. In contrast, the TR of the helical acquisition mode to which image reconstruction is performed from z-axis interpolation is closely related to the gantry rotation time and specific interpolation method applied [2]. Thus, because CT images are reconstructed from projection data corresponding to each detector and complex interpolation algorithms [2–4], the TR of the helical acquisition mode may not necessarily be equal to the gantry rotation time of a multi-detector CT [5].

Generally, the TR of conventional helical acquisition modes except the cardiac mode of a CT scanner is not accurately depicted in the specifications of the individual scanner [6,7]. Therefore, because the TR of a CT scanner is dependent on not only the gantry rotation time but also interpolation algorithms, it should be clarified by an actual measurement.

Taguchi et al. [8] reported that temporal resolution can be evaluated using a temporal sensitivity profile (TSP), defined as the temporal sensitivity distribution of the projection data in a reconstructed CT image, just as the longitudinal spatial resolution

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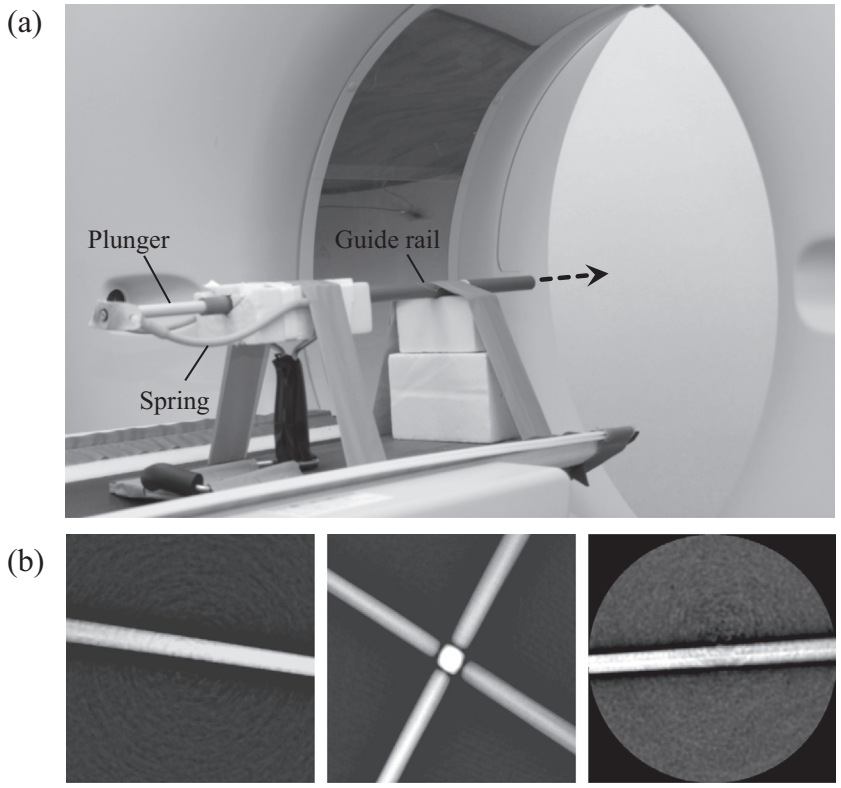

Figure 1. (a) Photograph of the launching platform for TR measurement. (b) Impulse response images of respective CT scanners: (left) SHM for DSCT, (middle) DHM for DSCT; (right) 64HM and 160HM for ADCT. The black arrow in the photograph indicates the flying direction of the small metal ball.

Table 1
CT acquisition and reconstruction settings for dual source computed tomography (DSCT) and area detector computed tomography (ADCT).

CT scanner	DSCT		ADCT	
Acquisition mode	SHM	DHM	64HM	160HM
Tube voltage (kVp)	120	120	120	120
Effective mAs	100	100	100	100
Rotation time (s/rot.)	0.285, 0.33, 0.5	0.285	0.275, 0.35, 0.5	0.3, 0.5
Detector configuration (mm)	64 × 0.6	2 × 64 × 0.6	64 × 0.5	160 × 0.5
Pitch factor	0.5, 0.75, 1.0, 1.25, 1.5	1.55, 2.0, 2.5, 3.0, 3.2	0.625, 0.75, 0.85, 0.9, 1.109, 1.2, 1.3, 1.375, 1.4, 1.5	0.596, 0.6, 0.65, 0.75, 0.85, 0.95
Slice thickness (mm)	0.75	0.75	0.5	0.5
Patient table increment (mm)	0.2	0.2	0.2	0.2
Display field of view (mm)	100	100	100	100
Reconstruction kernel	B26	B26	FC01	FC01

SHM: single source helical acquisition mode, DHM: dual source helical acquisition mode, HM: helical acquisition mode.

can be evaluated by the section sensitivity profile [9,10]. The TR is determined according to the full width at half maximum (FWHM) of the TSP. Taguchi et al. present the measurement results of the TRs for various reconstruction algorithms by incorporating the implanted temporal impulse signal into the projection data on computer simulations. Thus, if a temporal impulse signal into the reconstructed image (projection data) of commercial CT scanners can be generated by any method, assessment of the actual TR for all acquisition conditions is possible by TSP analysis. In response to this problem, we previously proposed a practical method to assess the TSP of all acquisition modes using an impulse theorem-based metrology (impulse method) [11].

In the present study, we analysed the TR and TSP shape of a modern CT scanner, such as a dual source CT (DSCT) scanner [12] and an area detector CT (ADCT) scanner [13] using the impulse method and assessed the actual maximum TR for particular helical acquisition modes.

Materials and methods

CT scanners

This study was performed using a 128-slice DSCT scanner (SOMATOM Definition Flash; Siemens Healthcare, Erlangen, Germany) and a 320-row ADCT scanner (Aquilion ONE ViSION Edition; Toshiba Medical Systems, Tokyo, Japan). The DSCT scanner is equipped with two X-ray tubes and two 64-row detector arrays mounted into the gantry with an angular offset of approximately 90°. The ADCT scanner is equipped with 320-row detector arrays that can obtain coverage of up to 160 mm in the *z*-direction. Image data obtained using the two CT scanners were transferred to a dedicated computer using the Digital Image and Communication in Medicine transfer protocol (DICOM) and were analysed using ImageJ image analysis software (ver. 1.47i; National Institutes of Health, Bethesda, MD, USA) [14].