**Supplemental file**

1. Equivalent dose of the virtual low-dose image

We assessed the virtual low-dose (low-dosevirtual) as follows. A circular water phantom was scanned at a diameter of 30 cm to measure the standard deviation (SD) of CT values. CTDIvol was determined based on the size-specific dose estimate (SSDE) to produce the data of patient-equivalent dose (CTDIvol = 22.5 mGy in standard dose image [std-dose]) [1]. The phantom was scanned using a CTDIvol of 18.3, 9.6 (half-dose), and 4.8 mGy (quarter-dose). The phantom images were reconstructed via filtered back projection (FBP). Low-dosevirtual images were reconstructed using the same conditions described in the Materials and Methods section.

Figure S1 shows the relationship between CTDIvol and image noise. The white circles represent the image noise obtained with the standard-, half-, and quarter-doses. Three data points were fitted using the nonlinear regression curve. The black circle represents the image noise in the virtual low-dose image. The equation in the graph is obtained using the nonlinear regression model. The equation model assumes that the image noise is inversely proportional to the root of the radiation dose. This graph indicates that the virtual low-dose image is equivalent to the data obtained between half- and quarter-doses.

2. Image quality using water phantom

We evaluated the image quality among std-dose, virtual low-dosevirtual, and low-doseactual images. The iodine rod of 2 mgI / mL (Kyoto Kagaku, Kyoto, Japan) was set at the center of the water phantom, as mentioned above (Figure S2). The iodine rod has approximately 50 Hounsfield unit, which is similar to the normal prostate [2]. Low-doseactual images were scanned using the quarter-dose of the std-dose image. All images were reconstructed via FBP, AIDR3D, and AIDR3D enhanced. The square region-of-interest (ROI) was set, as shown in Figure S2. We evaluated CT values, image noise (SD), and contrast-to-noise ratio (CNR). CNR was calculated using the following equation:

where CT valuerod and CT valuebg are the mean CT values in the iodine rod and the background, respectively. SDrod is the image noise corresponding to the standard deviation of the CT values of the iodine rod.

Table S1–S3 show the CT values, SD, and CNRs, respectively. The CT values were almost similar among the three images. The SD and CNR of the std-dose images were best among the three images. Low-dosevirtual and low-doseactual images had a similar quality.

3. Pelvis phantom

We compared the pelvis phantom among the std-dose and low-dosevirtual images. The std-dose image was scanned using a CTDIvol of 21.7 mGy, which was determined using SSDE. As shown in Figures S3-1 and S3-2, both images were reconstructed via adaptive iterative dose reduction (AIDR) 3D weak (a), mild (b), standard (c), and strong (d); AIDR3D enhanced mild (e), standard (f), and strong (g); and FBP (h). Images reconstructed via FBP had severe streak artifacts due to photon starvation. AIDR3D and AIDR3D enhanced improved the image noise and streak artifact; however, images reconstructed using the higher-strength IR technique presented with texture changes.

Figure S4 shows the image noise measured in the pelvis phantom. The bar graph shows the mean image noise in the 2- and 0.5-mm-thick images combined with various reconstruction kernels. The square ROI was set at the center of the pelvis phantom. The FBP image had a significantly higher image noise. AIDR3D and AIDR3D enhanced combined with the higher-strength IR technique was more effective in reducing image noise. The image noise was similar between the 2-mm-thick image reconstructed using AIDR mild (std-dose image) and the 0.5-mm-thick image reconstructed by AIDR enhanced strong (low-dose image).

References

1. D’Souza WD, Madsen EL, Unal O, Vigen KK, Frank GR, Thomadsen BR. Tissue mimicking materials for a multi-imaging modality prostate phantom. Med Phys. 2001;28:688-700.

2. Moore BM, Brady SL, Mirro AE, Kaufman RA. Size-specific dose estimate (SSDE) provides a simple method to calculate organ dose for pediatric CT examinations. Med Phys. 2014;41:071917.

**Figure legends**

Figure S1 Relationship between CTDIvol and image noise

Figure S2 Water phantom for the image quality assessment

Figure S3-1 Pelvis phantom images (2\_mm)

Figure S3-2 Pelvis phantom images (0.5\_mm)

Figure S4 Image noise measured in the pelvis phantom

**Tables**

Table S1 CT values of the iodine rods obtained at three dose levels

|  |  |  |  |
| --- | --- | --- | --- |
|  | CT values (HU) | | |
|  | Std-dose | Low-dosevirtual | Low-doseactual |
| FBP | 48.89 | 48.37 | 48.56 |
| AIDR3D |  |  |  |
| Weak | 48.85 | 48.37 | 48.55 |
| Mild | 48.85 | 48.43 | 48.37 |
| Standard | 48.86 | 48.47 | 48.44 |
| Strong | 48.81 | 48.39 | 48.42 |
| AIDR3D Enhanced |  |  |  |
| Mild | 49.09 | 48.91 | 48.9 |
| Standard | 49.00 | 48.82 | 48.83 |
| Strong | 49.00 | 48.89 | 48.95 |

HU: Hounsfield Unit, Std-dose: standard-dose, Low-dosevirtual: virtual low-dose, Low-doseactual: actual low-dose, FBP: filtered back projection, AIDR 3D: adaptive iterative dose reduction 3D

The CTDIvol of low-doseactual imagesis a quarter of that of std-dose images.

The slice thickness is a quarter of that of std-dose images(0.5 vs. 2.0 mm).

Table S2 Image noise obtained at three dose levels

|  |  |  |  |
| --- | --- | --- | --- |
|  | SD (HU) | | |
|  | Std-dose | Low-dosevirtual | Low-doseactual |
| FBP | 5.99 | 10.26 | 10.44 |
| AIDR3D |  |  |  |
| Weak | 5.72 | 9.73 | 9.12 |
| Mild | 4.65 | 8.01 | 7.39 |
| Standard | 3.73 | 6.96 | 6.15 |
| Strong | 3.26 | 6.28 | 5.51 |
| AIDR3D Enhanced |  |  |  |
| Mild | 3.56 | 6.66 | 6.64 |
| Standard | 3.17 | 6.11 | 5.92 |
| Strong | 2.58 | 4.95 | 4.93 |

SD: standard deviation, HU: Hounsfield unit, Std-dose: standard-dose, Low-dosevirtual: virtual low-dose, Low-doseactual: actual low-dose, FBP: filtered back projection, AIDR 3D: adaptive iterative dose reduction 3D

The CTDIvol of low-doseactual imagesis a quarter of that of std-dose images.

The slice thickness is a quarter of that of std-dose images(0.5 vs. 2.0 mm).

Table S3 Contrast-to-noise ratio (CNR) obtained at three dose levels

|  |  |  |  |
| --- | --- | --- | --- |
|  | CNR | | |
|  | Std-dose | Low-dosevirtual | Low-doseactual |
| FBP | 8.09 | 4.72 | 4.62 |
| AIDR3D |  |  |  |
| Weak | 8.47 | 4.98 | 5.3 |
| Mild | 10.43 | 6.04 | 6.5 |
| Standard | 13.01 | 6.97 | 7.82 |
| Strong | 14.85 | 7.71 | 8.74 |
| AIDR3D Enhanced |  |  |  |
| Mild | 13.65 | 7.31 | 7.28 |
| Standard | 15.28 | 7.95 | 8.16 |
| Strong | 18.81 | 9.81 | 9.82 |

Std-dose: standard-dose, Low-dosevirtual: virtual low-dose, Low-doseactual: actual low-dose, FBP: filtered back projection, AIDR 3D: adaptive iterative dose reduction 3D

The CTDIvol of low-doseactual imagesis a quarter of that of std-dose images.

The slice thickness is a quarter of that of std-dose images(0.5 vs. 2.0 mm).