Measurement of Single Scan Dose Profiles in Computed Tomography Dose Phantom Using a Micro Ionization Chamber

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Abstract As the X-ray beam widths for modern multi-detector-row CT (MDCT) scanners get wider, the current Computed Tomography Dose Index (CTDI) methodology based on the measurement of the integral of the single scan dose profile (SSDP) using 100-mm-long pencil ionization chamber ($CTDI_{100}$) may no longer be adequate. We measured the SSDP as D_m for several X-ray beam widths on 64-slice MDCT using a micro ionization chamber, and assessed the association of the $CTDI_{100}$ with phantom length. A micro ionization chamber was placed in the center (Z=0) of the single CT dose phantom (SDP), and we acquired several axial scans as 5 mm increments of phantom length. Then the two coupled CT dose phantom (TCDP) was placed together to simulate a 300-mm-long phantom, and we acquired several axial scans in similar method. The $CTDI_{100}$ value was calculated from the 100-mm-long integral dose of D_m. The observed percent increase of the D_m with extended length of CT dose phantom was 120 % at range from -60 to 60 mm. However, it was greatly increased toward peripheral of the SSDP. The $CTDI_{100}$ value was contained about 85 % for the SDP, 67 % for the TCDP. Both integral doses were no relationship to the X-ray beam widths. Some investigators shown the CTDI measurements in recent MDCT systems have been required to using longer CT dose phantoms. Generally, many institutes do not have longer CT dose phantoms in Japan. These results will become useful to decision of a guideline for CTDI dosimetry in recent MDCT systems.

Keywords: computed tomography (CT), CT dosimetry, CTDI, dose profile, micro ionization chamber

1. Objective

As the X-ray beam widths for modern multi-detector-row CT (MDCT) scanners get wider, the current Computed Tomography Dose Index (CTDI) methodology based on the measurement of the integral of the single scan dose profile (SSDP) using a 100-mm-long pencil ionization chamber ($CTDI_{100}$) may no longer be adequate. We measured the single scan dose profile (SSDP) in computed tomography (CT) dose phantom for several X-ray beam widths on 64-slice Multi-Detector-Row CT (MDCT) using micro ionization chamber.

2. Materials and Methods

The SSDP was measured as Dm using radiation monitor (Model 9015, Radcal, Monrovia, CA) with micro ionization chamber (10X5-0.18, Radcal, Monrovia, CA) which have an active length of 19 mm and a 0.18 cm^3 active area (as shown Fig. 1) on 64-slice MDCT (Aquilion CX, Toshiba Medical Systems, Nasu, Japan). The 64-slice MDCT was used with a tube voltage of 120 kV, tube current of 200 mA, rotation time of 1 second, and nominal X-ray beam widths of 4, 12, and 32 mm (4*1 mm, 4*3 mm, and 64*0.5 mm axial slice acquisitions, respectively). A micro ionization chamber was placed in the center (z=0) of the single CT dose phantom (SDP), and we acquired several axial scans as 5 mm increments of phantom length, 0.5 mm increments in peripheral area of the center (-10 to 10 mm). Then two coupled dose phantoms (TCDP) was placed together to simulate a 300-mm-long phantom, and we acquired several axial scans in similar method (as shown in Fig. 2, 3). The $CTDI_{100}$ value was calculated from the 100-mm-long integral dose of D_m

Fig. 1 10X5-0.18 Micro Ionization Chamber

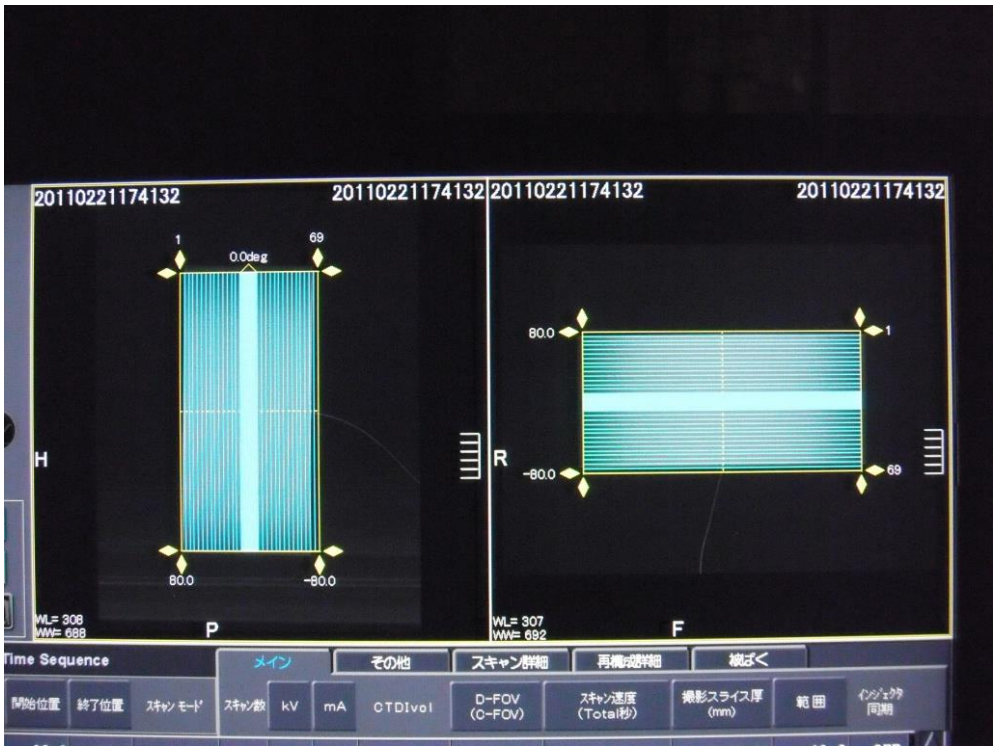

Fig. 2 Experimental setup of the SSDP measurement in single CT dose phantom

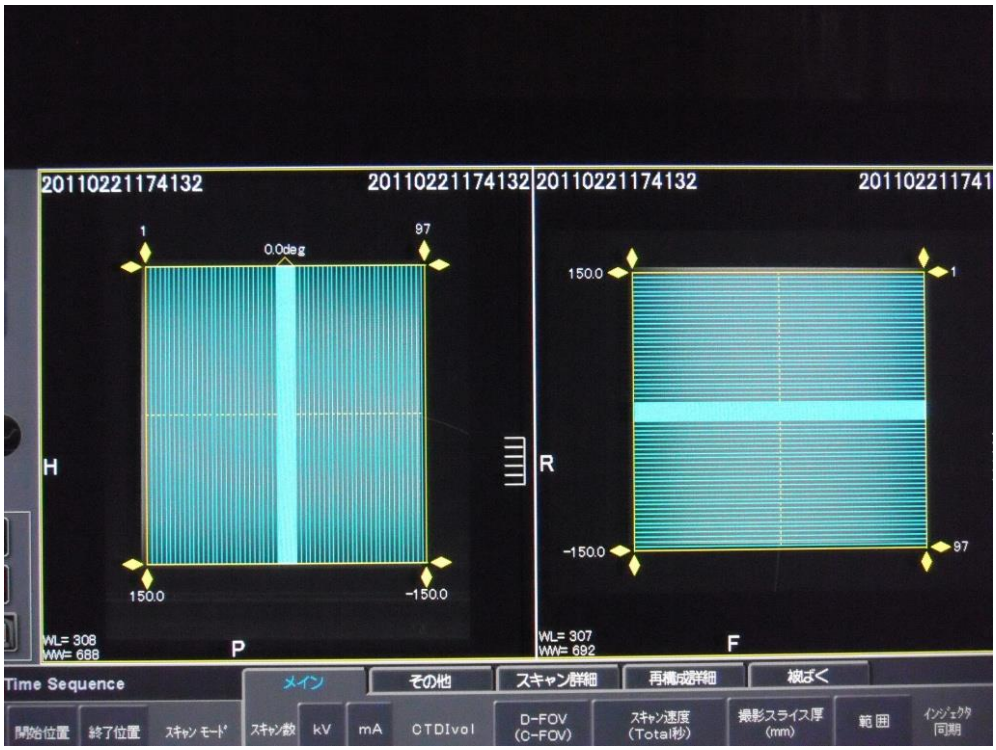

Fig. 3 Experimental setup of the SSDP measurement in two coupled CT dose phantom

3. Results

Figure 4-6 shows the SSDPs were measured by a micro ionization chamber with the several X-ray beam widths. The observed percent increase of the D_m with extended length of the CT dose phantom was 120 % at range from -60 to 60 mm. However, it was greatly increased toward peripheral area of the SSDP (as shown Fig. 7). The $CTDI_{100}$ value (as shown yellow area on Fig. 8-10) was contained about 85 % for the SDP, 67 % for the TCDP. Both integral doses were no relationship to the X-ray beam widths.

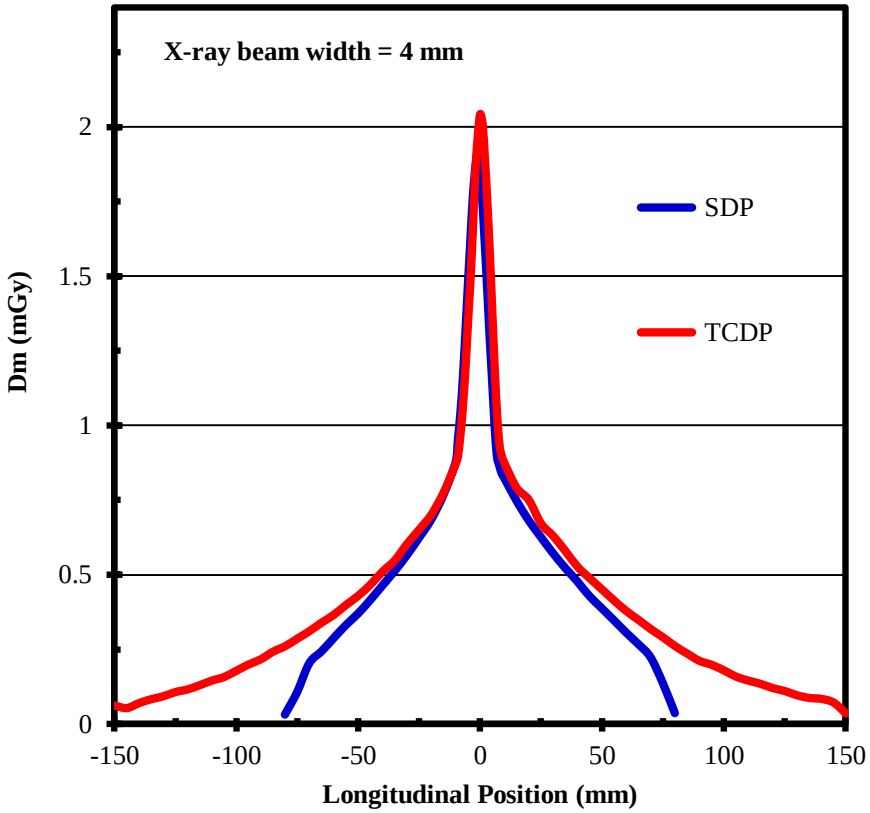

Fig. 4 The SSDP with 4 mm X-ray beam width

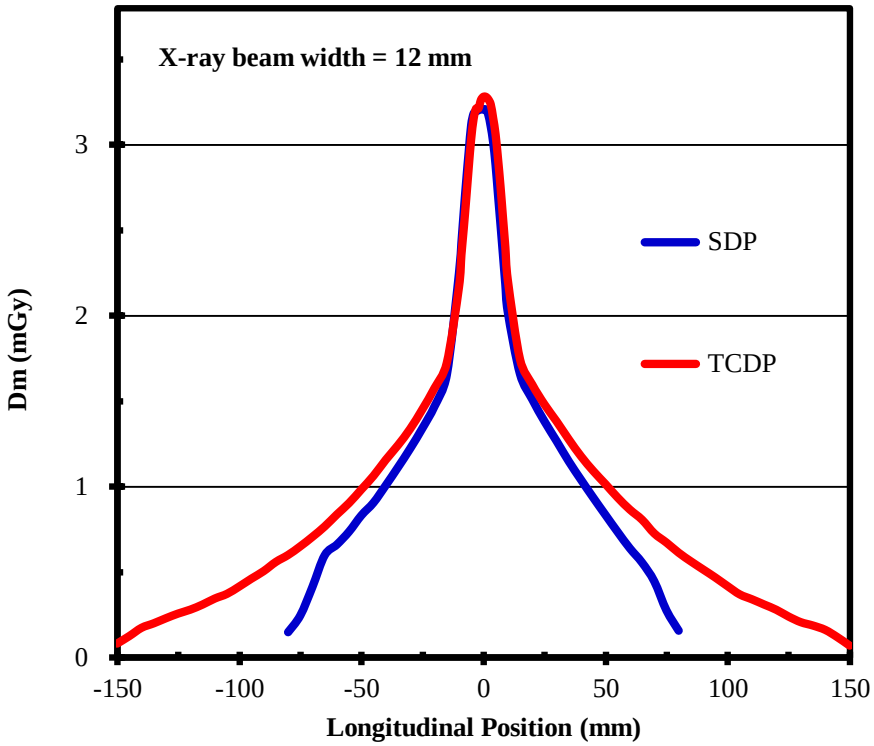

Fig. 5 The SSDP with 12 mm X-ray beam width

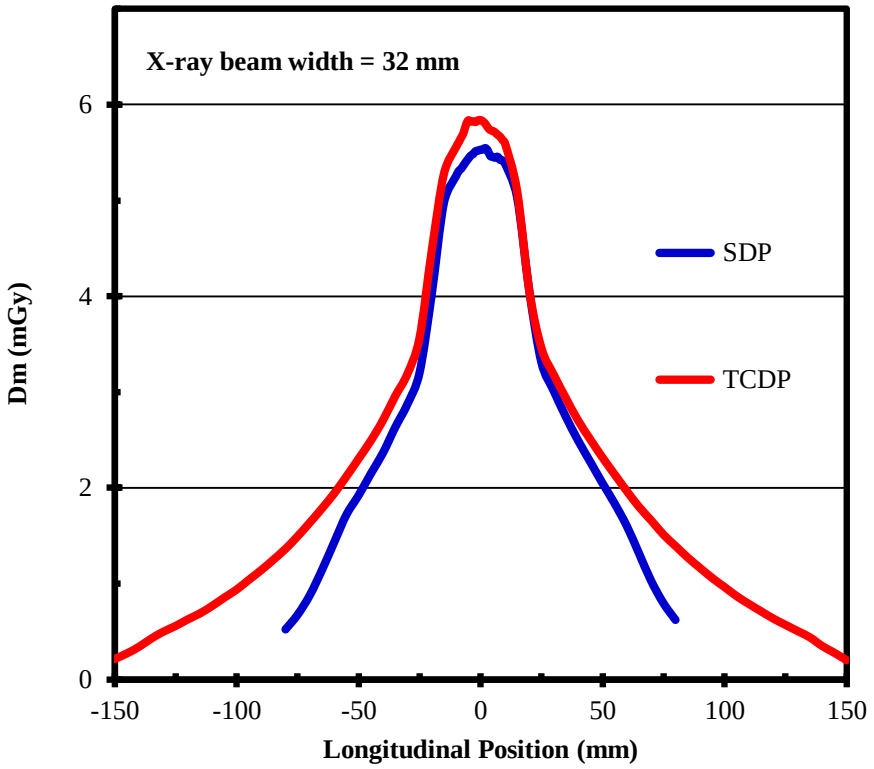

Fig. 6 The SSDP with 32 mm X-ray beam width

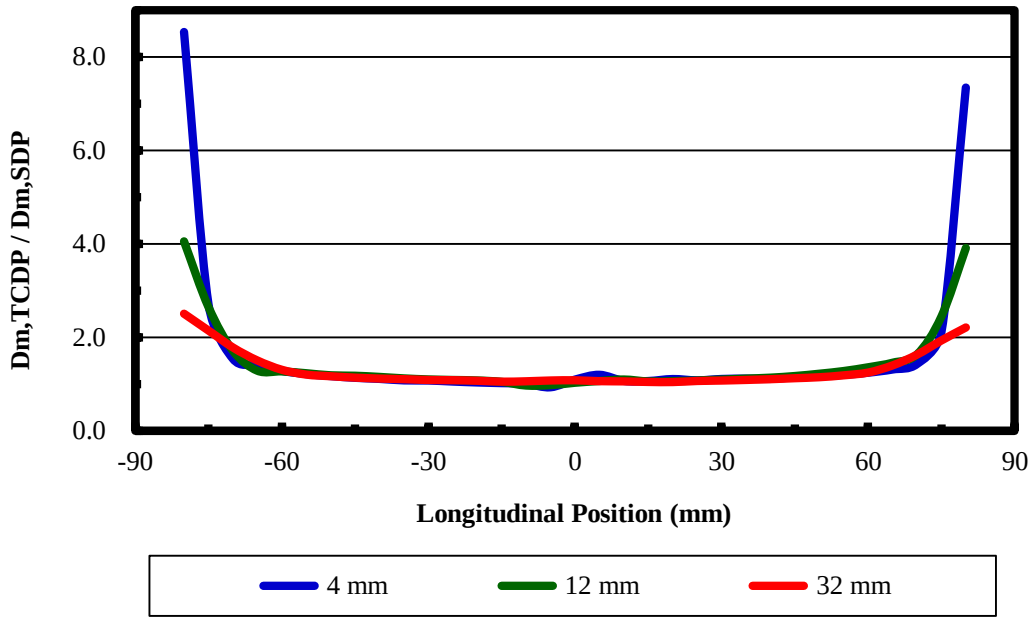

Fig. 7 Increment of D_m ($D_{m,TCDP}$ /$D_{m,SDP}$) for several X-ray beam width versus longitudinal position of CT dose phantom

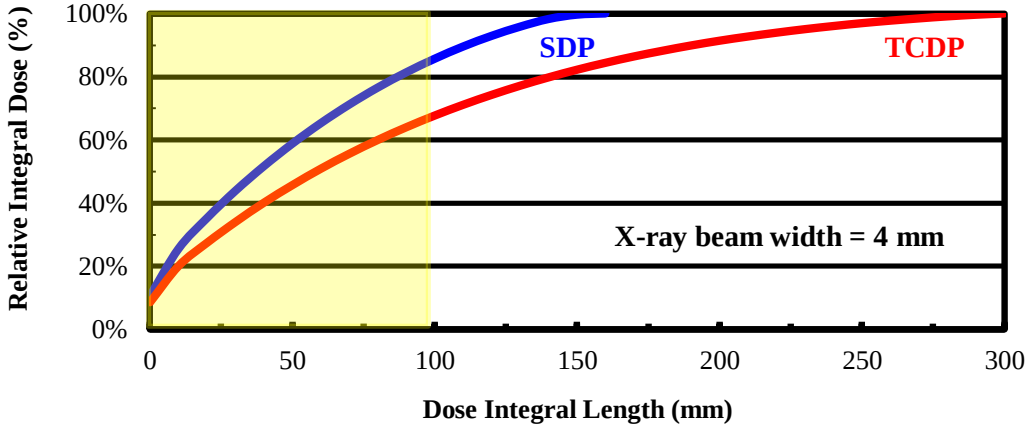

Fig. 8 Integral Dose of SDP and TCDP in 4 mm of X-ray beam width

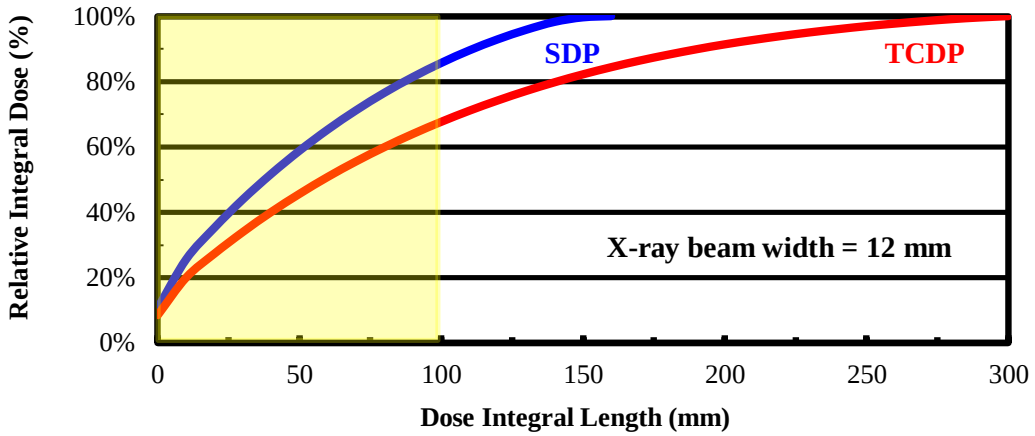

Fig. 9 Integral Dose of SDP and TCDP in 12 mm of X-ray beam width

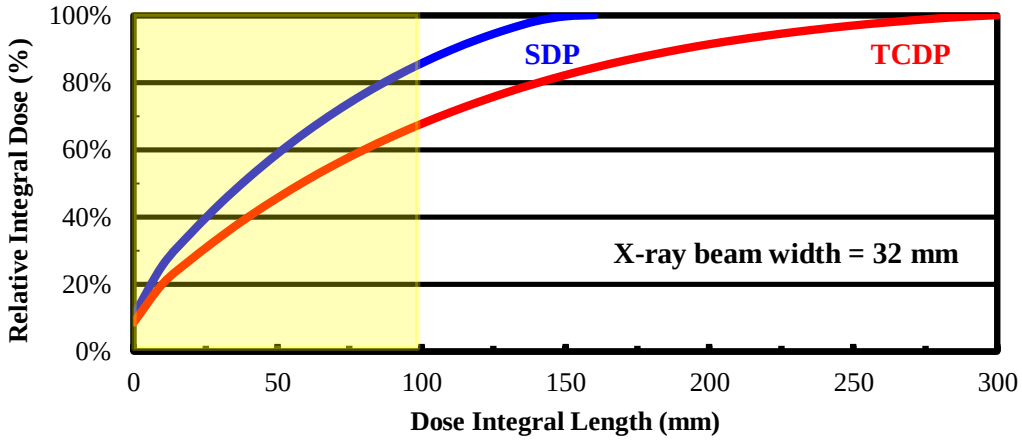

Fig. 10 Integral Dose of SDP and TCDP in 32 mm of X-ray beam width

4. Conclusion

Some investigators shown the CTDI measurements in recent MDCT systems have been required to using longer CT dose phantom. Generally, almost facility in Japan not have longer CT dose phantom. These results will become useful to decision of a guideline for CTDI dosimetry in recent MDCT systems.

5. References

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