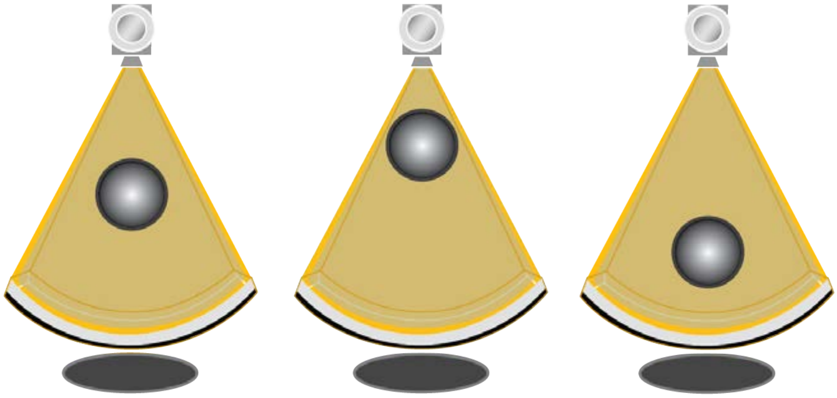
TOSHIBA

Leading Innovation >>>

Auto Couch Height Positioning Compensation – Making SUREExposure a Smarter Dose Reduction Tool



By Di Zhang

Manager, Clinical Science, CT,
Toshiba America Medical Systems

Rodrigo Ayala

Manager, Clinical Marketing, CT,
Toshiba America Medical Systems

Tube current modulation (TCM) is one of the commonly used strategies to reduce the radiation dose from CT (Kalra, 2004). TCM techniques allow the modulation of X-ray tube current both within the axial plane and along longitudinal direction throughout the entire scan based on the unique size and shape of individual patients (Gies, 1999). This technique maintains constant image noise level across different projections and greatly improves the dose efficiency of a CT system.

SUREExposure™ 3D is a sophisticated suite of tube current modulation technologies integrating acquisitions and reconstruction with an advanced dose reduction algorithm (Angel, 2009). SUREExposure 3D determines the size- and shape-dependent attenuation information for an individual patient from the scanograms (localizer radiographs). The attenuation information is then converted into "water equivalent thickness," and the algorithm calculates the amount of tube current needed to achieve the target image quality level specified by the user based on the task at hand.

The mis-centering of the patient within the CT gantry could cause some unexpected effects when tube current modulation is used. Because a localizer radiograph is acquired at a specific projection, mis-centering of the patient could cause inappropriate magnification of the object, leading to inaccurate estimation of the attenuation information. For example, for a localizer radiograph along anterior-posterior (AP) direction, if the patient is positioned at the center of the gantry (Figure 1a), the magnification of the object is accurate. If the patient is positioned too high (Figure 1b), the localizer radiograph is over-magnified, resulting in overestimation of the patient attenuation and higher tube current, as well as an unnecessary increase in radiation dose for the study. On the other hand, if the patient is positioned too low (Figure 1c), the localizer radiograph is under-magnified, resulting in underestimation of the attenuation and lower tube current, as well as excessive noise for the images.

Several studies have investigated the consequences of patient mis-centering for CT scans with tube current modulation. Matsubara et al. concluded that the average tube current ranged from 24% to negative 18% when an oval shaped phantom was positioned from 5 centimeters above to 5 centimeters below the gantry center (Matsubara, 2008). Gudjonsdottir et al. found that the average tube current varied by up to positive 70%, negative 34% and positive 56% for three different scanners when a phantom was positioned in various off-center positions within the 500 millimeter field of view (Gudjonsdottir, 2009). Rong et al. also discovered over 40% change in CTDIvol when the table height changed from 10 centimeters below the gantry center to 10 centimeters above the gantry center (Rong, 2013).

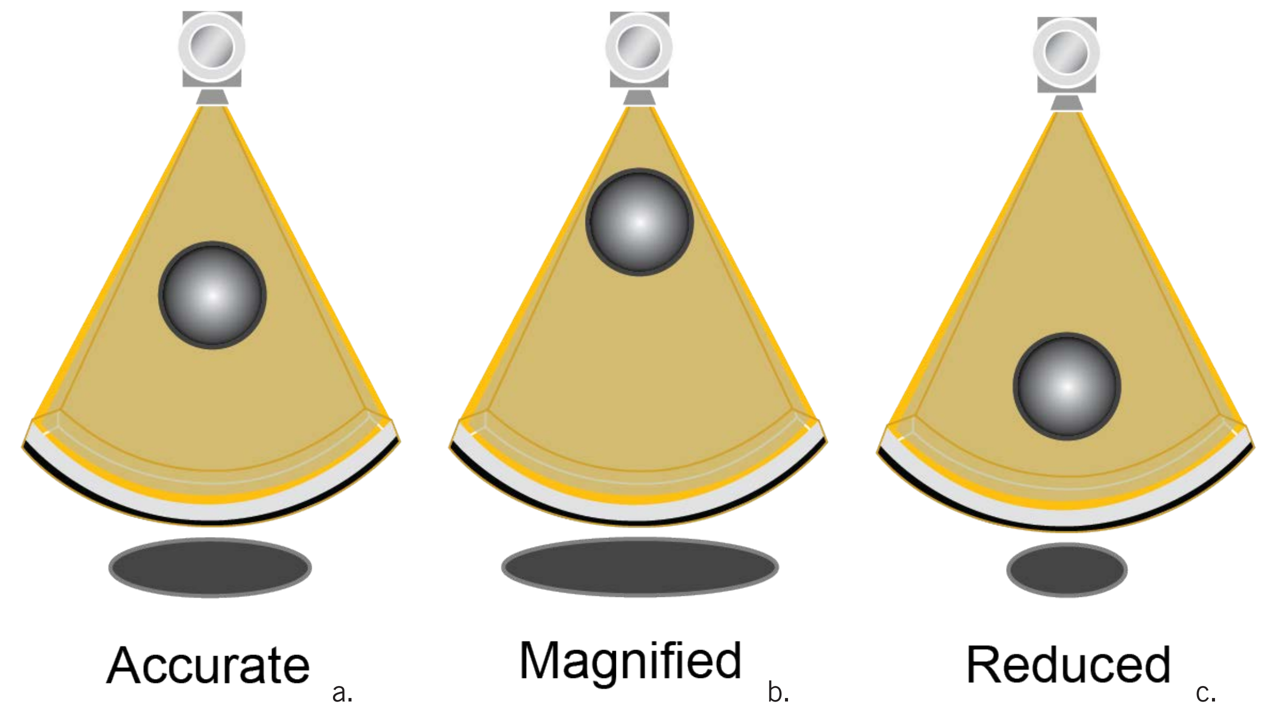


Figure 1: Mis-centering of the patient could causes inaccurate estimation of the attenuation. a) the patient is positioned at gantry center; b) the patient is positioned too high in the gantry, causing elevated tube current; c) the patient is positioned too low in the gantry, causing insufficient tube current.

Given this property of tube current modulation, it is important to appropriately center the patient. However, in practice, it is sometimes challenging to achieve accurate centering for every single patient for several reasons. First, patients don't have a perfectly cylindrical shape. Therefore, the definition of the center of the patient can be arbitrary. Therefore, there could be large variability in terms of "patient center" across institutions and technologists even when efforts are made to carefully center the patients. Second, it is impossible to find a universal patient center for multi-region studies, such as neck, chest and abdomen scans. Lastly, for patients who cannot lie flat and who have to elevate their head or chest during the study, or who are on a life support system, it is difficult to center them in the CT gantry. In a study in 2008, it was summarized that 232 out of the 243 patients investigated were not positioned accurately in the gantry center (Li, 2008).

SUREExposure Positioning Compensation

As a continuous commitment to patient safety, Toshiba has developed a positioning compensation technology integrated in SUREExposure 3D tube current modulation in its latest software version. This technology allows accurate estimation of the attenuation information for individual patients even when the patient is not well centered in the CT gantry, ensuring low radiation dose and consistent image quality in a broad range of clinical situations.

As shown in Figure 2, the positioning compensation technology automatically detects the offset between patient position and the gantry center, compensates the estimation of attenuation by taking into account this offset and generates consistent tube current despite the mis-centering of the patient.

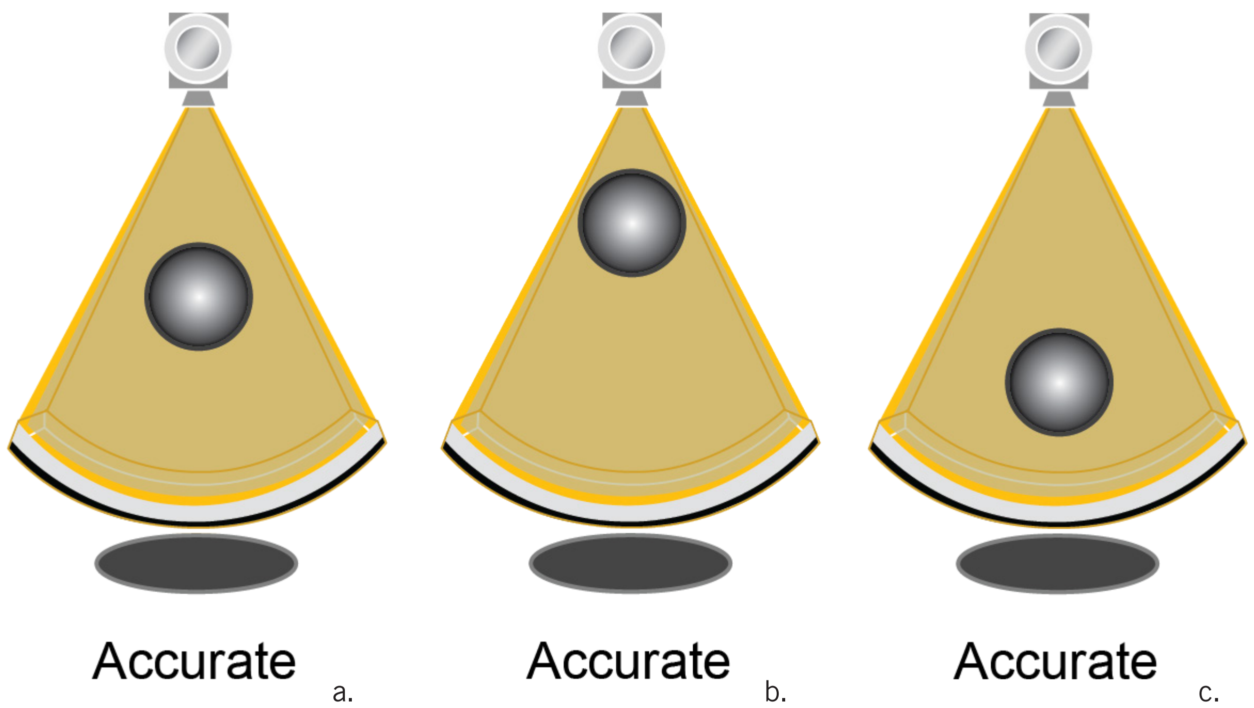


Figure 2: The positioning compensation technology automatically compensates for the incorrect magnification resulting from the mis-centering of the patient. a) the patient is positioned at gantry center; b) the patient is positioned too high in the gantry, but the tube current is still consistent; c) the patient is positioned too low in the gantry, but the tube current is still consistent.

To demonstrate the benefit of this technology, an anthropomorphic phantom was scanned at different table heights on an Aquilion™ ONE ViSION Edition CT scanner with the positioning compensation technology integrated in the SUREExposure 3D tube current modulation package (shown in Figure 3). The PIXY® phantom (Pacific Northwest X-Ray Inc.) with the height of 5 feet 1 inch, and the weight of 105 lbs., designed for training radiologic technologists, was used in this experiment. It contains multiple organs made of bone-, soft tissue- and lung tissue-equivalent materials. A typical body protocol was used and the exams covered both chest and abdominal regions. As a comparison, similar exams were performed on another system without the positioning compensation technology. The $CTDI_{vol}$ values for exams performed at different table heights for systems with and without positioning compensation technology are shown in Figure 4. Figure 4 shows that when the technology is used, the radiation output is much more consistent across table positions ranging from 7.5 centimeters below the gantry center to 7.5 centimeters above the gantry center.

The tube current for each individual slice was extracted from the DICOM header and plotted as a function of the table location along z direction. These are shown in Figure 5 for scans with and in Figure 6 for scans without positioning compensation technology. For all the exams, the tube current has a general increasing trend as the table moves further along z direction (from chest region to abdomen region). This is because the abdomen region is more attenuating than the chest region, requiring more tube output in order to achieve the same image quality level.

Figure 3: An anthropomorphic phantom was scanned at multiple table heights to demonstrate the benefit of positioning compensation technology.

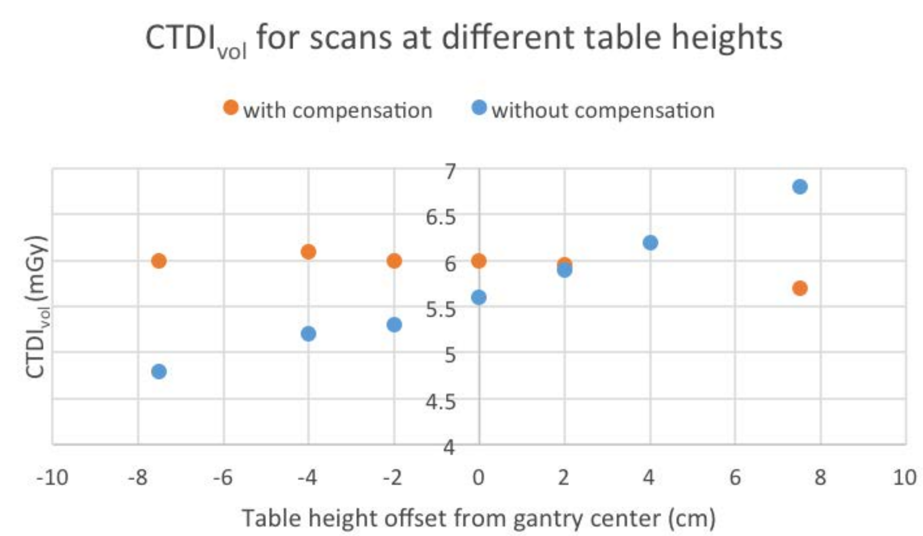


Figure 4: $CTDI_{vol}$ at different table heights for systems with and without the positioning compensation technology. With this technology, the radiation output is much more consistent across different table heights.

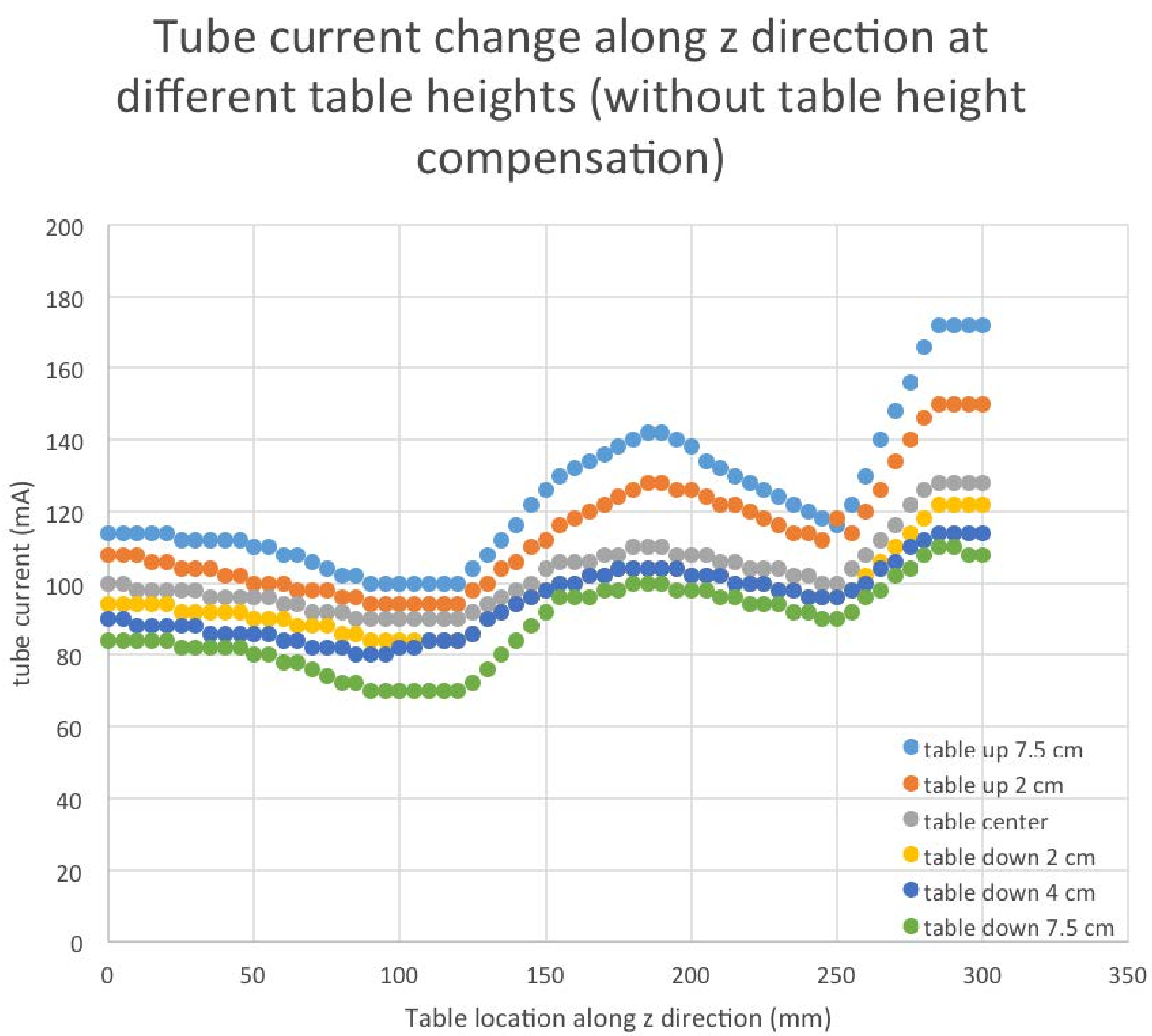


Figure 5: Tube current (mA) as a function of table location along z direction for scans performed at different table heights for a system without positioning compensation technology. A systematic behavior of tube current modulation scheme is observed as the table height changes.

Figure 5 shows that without the positioning compensation technology, as the table moves higher, the magnification of the phantom increases, leading to higher estimation of attenuation and therefore higher tube current. On the other hand, Figure 6 shows that when the positioning compensation technology was used, there was no systematic difference of the tube current modulation schemes across different table heights.

Conclusion

At Toshiba, CT dose and safety is not a choice, and that commitment mandates continuous development of technologies that enhance patient safety and facilitate workflow. The positioning height compensation technology integrated in SUREExposure circumvents the challenge of patient mis-centering in regular tube current modulation approaches and assures the quality of the studies without compromising the workflow.

Besides patients who cannot be perfectly centered, this technology is also of great benefit for pediatric patients because they are more likely to be mis-centered due to larger space within the gantry. Positioning compensation technology ensures appropriate radiation output for specific tasks even when the patient is mis-centered, delivering consistent radiation dose and image quality.

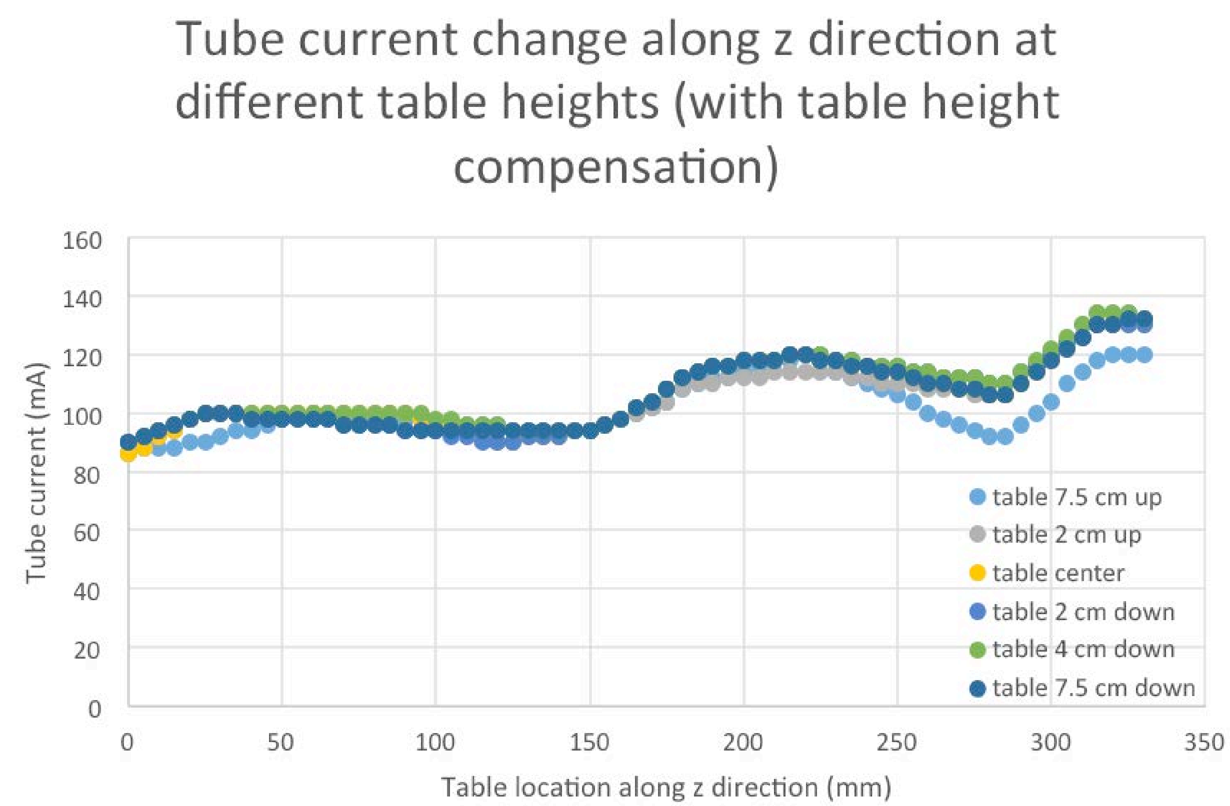


Figure 6: Tube current (mA) as a function of table location along z direction for scans performed at different table heights for a system with positioning compensation technology. There is no systematic difference of the tube current modulation schemes across different table heights.

References:

Angel, E. (2009). SUREExposure™ Low Dose Diagnostic Image Quality. Tustin, CA: Toshiba America Medical Systems.

Gies, M. (1999). Dose reduction in CT by anatomically adapted tube current modulation. I. Simulation studies. Medical Physics, 26, 2235.

Gudjonsdottir, J. (2009). Efficient use of automatic exposure control systems in computed tomography requires correct patient positioning. Acta Radiolo, 1035-1041.

Kalra, M. (2004). Techniques and Applications of Automatic Tube Current Modulation for CT. Radiology, 649-657.

Li, J. (2008). Application of automatic vertical positioning software to reduce radiation exposure in multidetector row computed tomography of the chest. Investigational Radiology, 447-452.

Matsubara, K. (2008). Misoperation of CT Automatic Tube Current Modulation Systems with Inappropriate Patient Centering: Phantom Studies. American Journal of Roentgenology, 862-865.

Rong, J. (2013, March 15). TUBE CURRENT MODULATION. Retrieved from AAPM: http://www.aapm.org/meetings/2013CTS/documents/Fri_10SupanichTCMFinal.pdf

www.medical.toshiba.com

TOSHIBA AMERICA MEDICAL SYSTEMS, INC.

2441 Michelle Drive, Tustin CA 92780 / 800.421.1968

CTWP12271US