**Effects of Metal Artifacts of kV and MV CT Images on Structure Delineation and Tissue Electron/Mass Density Calculation**

**Purpose**: The streak artifacts of CT images caused by high Z metal implants can considerably distort the HU numbers of surrounding tissues. Errors are consequently introduced to the anatomical structure delineation and tissue electron and mass density calculation that are based on HU numbers. The errors are subsequently passed on to the dose calculation of CT based treatment plans. This study was to quantitatively evaluate the effects of the image artifacts of hip prostheses on the accuracy of structure delineation and tissue density calculation respectively on kV and MV CT images.

**Method and Materials**: Five different types of hip prostheses were used. The implant materials include stainless steel, titanium and cobalt chrome alloys. Metal implants were attached onto three solid water blocks (Fig. 1) submerged in a tank of water 28 cm wide and 18 cm high (Fig. 2). The tank was scanned respectively on a Philips Big Bore CT with 140 kV and 3 mm slice and a Tomotherapy Hi-Art unit with 3.5 MV and 4 mm slice. Five prostheses were positioned to mimic the single and bilateral hip prosthesis implantation geometries. Rods (7.1 cm long and 2.8 cm in diameter) of three tissue materials of a GAMMEX CT phantom (LN-300 Lung, CT solid water and SB3 cortical bone) were respectively placed at locations next and distal to the metal implants in the regions of femoral head, neck and stem of prostheses. kV and MV CT scans were repeated for each rod placement. On the acquired CT scans, cross-sectional outlines of metal implants and rods were delineated. Electron and mass densities of rod materials were determined based on the pre-calibrated HU-number-to-density conversion curves and compared to the known values.

**Results**: Streaks of metal artifacts were seen on both kV and MV CT images. Artifacts on kV CTs were severe while those on MV CTs were minimal (Figs. 3 and 4). The cross-sectional outlines of metal implants and the rods of tissue materials on kV CTs were severely distorted by artifacts while those on the MV CTs remained clearly identifiable. For kV CTs, the deviations of measured tissue density from the true value were up to 51.3%, 30.6% and 40.9% respectively for lung, bone and solid water. The magnitude of deviation was generally larger at locations closer to the metal implants and greater with bilateral implants than single implant. In contrast, for MV CTs, the deviations of measured density from true value were less than 6% for all the three studied tissue materials with single and bilateral implants. Magnitude of deviation appeared to be uniform throughout and independent of locations relative to metal implants.

**Conclusion**: Artifacts on kV CTs caused by high Z metal implants can have severe impact on the accuracy of structure delineation and tissue density calculation, while on MV CTs the impact of artifacts is substantially less and insignificant. MV CTs should be considered for treatment planning purpose on patients with metal implants.

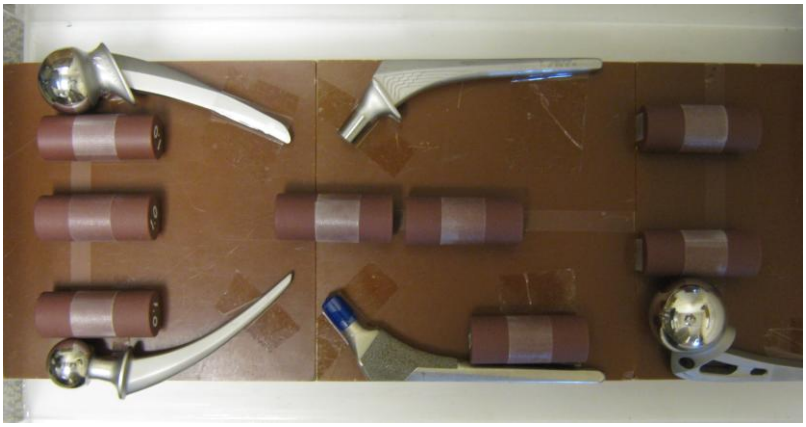
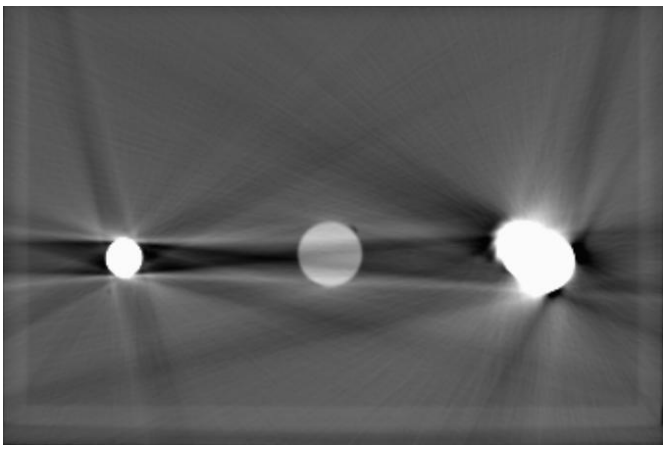


Fig 1. (Left) Five different types of hip prostheses were attached onto blocks of solid water to mimic hip implantation with single and bilateral prostheses. Rods of three different tissue materials were respectively placed at various locations to study the effects of metal artifacts on HU numbers of these materials.

Fig. 2. (Right) Solid water blocks with the attached metal implants and rods of tissue materials were submerged in a water tank. kV and MV CT scans were repeated for individual placement of tissue materials at different locations.



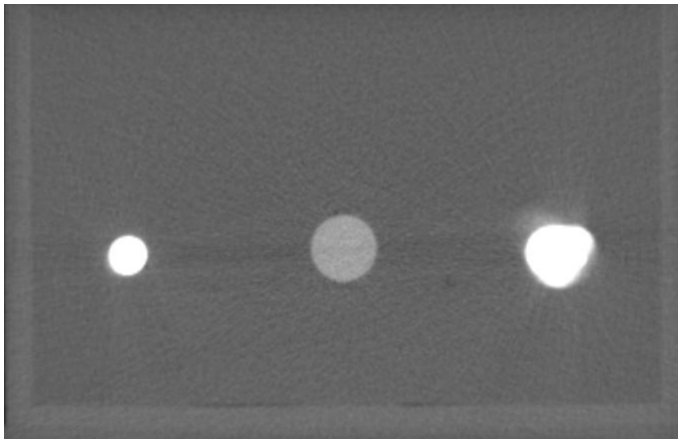


Fig 3. (left) A kV CT slice scanned with bilateral implants and a bone tissue rod in between. Severe artifacts distort the HU numbers in the rod. Edge outlines of both metal implants and the bone tissue rod are also corrupted.

Fig 4. (right) A MV CT slice scanned at the same location as in Fig. 3. Artifacts on MV CT slice are more subdued than those on kV CT slice. Edge outlines of both metal implants and the bone tissue rod can be clearly seen.