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Investigation of radiation dose and image quality in flat detector-based fluoroscopy and cone beam CT system

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The emergence of digital flat panel detector (FPD)-based fluoroscopy and cone-beam computed tomography (CBCT) system provides real-time 2D image influoroscopy and three-dimensional (3D) visualization with sub-millimeter spatial resolution. A modern CBCT system with C-arm and closed O-arm gantry incorporating a large-area flat-panel detector is widely used as a modality for diagnosis and image-guidance in spine surgery, orthopedic and interventional suite and image guide radiation therapy.
In this research, the prototype volume CT imaging platform consists of a single rotation gantry that is integrated with a cone-beam X-ray tube, filters, a collimator, an anti-scatter grid, and a large-area TFT based flat panel detector. This detector provides an active area of 400 x 300 mm2 including a 2,048 x 1,536 matrix array with 194-um pixel pitch as well as 7.5 fps and 30 fps. Scatter as the main reason limiting image quality in CBCT has been shown to reduce the contrast of soft-tissue structures, increase image noise and introduce streak artifacts. Different anti-scatter grids with a grid ratio (GR) of 8:1-12:1 with 80 line-pairs/cm and Al or carbon interspacing was used to optimize the scan protocols for specific imaging tasks such as head, thorax and abdomen surgery.The different projection images were usually acquired at various rotation angles with a constant gantry interval with a tube voltage of 80–120kVp, and different current (10–50mA) conditions. The performance evaluation of X-ray imaging quality was carried out using the FDK reconstruction algorithm through acquired 2D projection images at different gantry positions. The quantitative evaluation of image quality was investigated by using the cone beam CT phantom (QRM GmbH, Erlangen, Germany) for contrast resolution, spatial resolution, noise and modulation transfer function(MTF). The radiation dose associated with imaging task-specific protocols was investigated through acrylic CTDI head and body phantoms for central and peripheral dose measurement. The correlation between radiation dose and images quality of fluoroscopic and reconstructed 3D images were investigated for different scan protocols.

Primary author: CHA, Bo Kyung (KERI)

Co-authors: Prof. SEO, Chang-woo (yonsei university); Dr JEON, Sungchae (KERI)

Presenter: CHA, Bo Kyung (KERI)

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