Developing Low Dose CT-Like Imaging for Temporomandibular Joint (TMJ) Disorder in Interventional Radiology

Purpose

Manufatures have provided 3D rotational angiography and CT-like imaging technologies for applications in Interventional Radiology suites in recent years. The integrated 3D features have added a convenient clinical tool to Interventional Radiology suites. However, the radiation dose from these diagnostic technologies has not been analyzed, studied, or reported. Manufacturers rarely provide study-specific settings for various clinical applications. The default settings may provide satisfactory images. However, they are not necessarily optimized for effective use using variation dose for the specific clinical tasks.

The purpose of this study is to develop optimized settings for clinically acceptable 3D imaging of the Temporomandibular Joint (TMJ) in Interventional Radiology, using a 3D imaging angiography system, and to provide guidelines for clinicians to select the lowest possible radiation dose settings while satisfying their clinical needs especially for children.

Methods

Rotational angiographic scans (DynaCT, Siemens AXON-Artis) were performed with a flat panel digital x-ray imaging geometry (a 5.7-cm old custom designed anthropomorphic phantom. The phantom has 3 pencil-irradiation phantom kits allowing measurements similar to that of a standard CT Dose Index (CTDI) phantom. The CTDI was measured for TMJ specific scans using various time projection increments), dose settings, and Cu filter selections. The pencil-irradiation phantom was placed at 3 locations for measurements of the CTDI (at center, and at 1-cm from the edge at 3.5, 8, and 18 o'clock). The CTDI for each combination of parameters was calculated and compared with that of conventional CT for TMJ that are automated low-dose protocols (Siemens Somatom 64, at 80kVp, 25 Reference mAs) on the phantom. The study also investigated the effectiveness of using Cu-filters to remove low energy photons and reduce radiation doses. The 3D phantom images of the temporomandibular joint from DynaCT were reviewed by IR radiologists to evaluate clinical acceptance.

Results

The standard default setting provided by the manufacturer is an 8-second rotational scan, at 0.5 degree increment and a total of 360 frame projections. The default receptor dose setting is 0.36 microGy per frame. Standard DynaCT does not automatically insert Cu-filtration for removing low energy photons. For a typical 5 year old, the DynaCT 3D TMJ scan gives an equivalent CTDI of 4.4 mGy without anti-scatter grid, 2.9 mGy with the anti-scatter grid.

In comparison the CTDI for routine clinical CT of the TMJ for the same 5 year old phantom was 0.6 mGy.

The significant radiation dose consequences from DynaCT prevent Interventional Radiologists from using the DynaCT for TMJ without hesitation. However, DynaCT is clearly an effective and important clinical utility for TMJ study in the IR suite.

We have validated the manufacturer's 8-second rotational scan setting and 0.5 degree increment angle and 360 frame projections, and 2.9 microGy per frame, and 4.4 mGy without the Cu-filters. We also investigated the image quality change with short rotation time (less projection increment angle).

The images of the phantom with different combinations of settings were presented to and accepted by the Chief Interventional Radiologist for TMJ studies based on visual assessment of the quality of the DynaCT images.

Due to the high contrast of temporomandibular joint and injection needles on TMJ DynaCT images, the Interventional Radiologists could tolerate high level of the noise in the images. The Interventional Radiologists have gradually moved toward optimized low receptor doses and use modified parameters based on the guidance of phantom images and confidence in their satisfactory diagnosis.

We have achieved the optimized technique settings for TMJ with a 5 second rotation, at 0.5 degree increment angle and a total of 128 frame projections. The receptor dose was optimized to 0.10 microGy per frame. The optimized settings of the TMJ study achieved a total dose reduction of 87%, of which, 85% was due to the reductions of the necessary receptor dose and number of projections, and 10% was due to the addition of Cu-filters. The dose is about 1/2 without grid to 0.9 mm Cu-filters of the radiation dose from that of a conventional low dose CT TMJ.

Conclusion

Use of Cu-filters, short rotation time, and low dose settings significantly reduced radiation dose of rotational angiography for TMJ from that of the standards. This phantom study to clinical application process has successfully guided the clinical implementation of low dose (8-12 sec) studies for all ages in our institution. The dose reductions predicted by this phantom study have been demonstrated by each patient’s Exaire Protocol.

References