Performance Evaluation of the GE eXplore CT 120 Micro-CT for Various Scanning Protocols

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INTRODUCTION

Micro computed tomography (micro-CT) is a scaled down CT-imaging modality for small animals. Increased interest in *in vivo* preclinical imaging has promoted huge technical developments, making micro-CT a useful tool to study tissue morphology and disease status in small animals. Most of the current micro-CT scanners provide a set of scanning protocols designed to meet the image quality requirements of particular study types. These protocols mainly differ by the tube voltage, the current and the exposure time. The purpose of this work was to evaluate the performance of the General Electric (GE) eXplore CT 120 micro-CT scanner for various scanning protocols using the same methodology and image quality assurance vmCT phantom developed for the GE eXplore Ultra [1].

MATERIAL & METHODS

- **vmCT phantom (Fig. 1a):** a single phantom consisting of six separate modular sections (resolution coils, slanted edge, geometric accuracy, CT number evaluation, linearity, uniformity and noise) each designed to evaluate one aspect of image quality. The phantom fits the scanner field of view, allowing all the quantitative information to be obtained from a single scan.
- **QRM phantoms:** the QRM low contrast phantom (Fig. 1b), a resin cylinder containing small cylindrical inserts at a specified low contrast with respect to the background was used to measure the contrast to noise ratio for the different inserts. The QRM BarPattern phantom (Fig. 1c) was used to visually evaluate the spatial resolution.

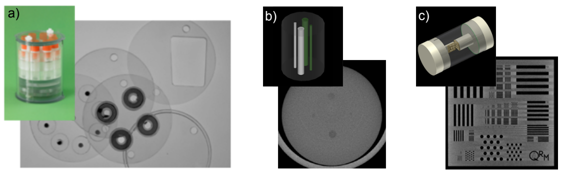

Figure 1: micro-CT phantoms a) vmCT phantom and its modular plates (SHELLEY MEDICAL IMAGING TECHNOLOGIES simutec.com); b) and c) QRM low contrast and BarPattern phantoms (Quality Assurance in Radiology and Medicine .qrm.de).

- **The six scanning protocols** regularly used in our laboratory (Table 1) were studied with the three phantoms.

Table 1: Scanning protocols parameters.

Protocols	Projections (views)	Gantry rotation (°)	Exposure time (ms)	Detector binning mode	Voltage (kV)	Current (mA)
Fast scan 220 (P1)	220	193	16	4x4	70	32
Fast scan 360 (P2)	360	360	16	4x4	70	32
Soft tissue fast scan (P3)	220	193	32	2x2	70	50
Soft tissue step & shoot (P4)	220	193	16	4x4	80	32
Low Noise (P5)	720	360	20	2x2	100	50
In Vivo bone scan (P6)	360	360	20	2x2	100	50

- Data reconstruction: Feldkamp's filtered back-projection algorithm was used to reconstruct the data into a 3D volume with a voxel size of 100 x 100 x 100 or 50 x 50 x 50 μm^3 depending on the protocol detector-binning mode.
- Data analysis was performed using PMOD software, version 3.3 (PMOD Technologies Ltd, Zurich, Switzerland), and Matlab software (www.mathworks.com, version 7.7).

RESULTS & DISCUSSION

Spatial resolution: the modulation transfer function (MTF) of the system was determined over a frequency range from 0 to 6 mm^{-1} based on the analysis of the reconstructed images of the coil and slanted edge sections for all protocols (Fig. 2). The 10% MTF for the slanted edge was in the range 3.6-4.8 mm^{-1} (P1&2 = 4.2; P3&4 = 4.8; P5 = 3.5 and P6 = 3.8), corresponding to a spatial resolution between 95 and 138 μm.

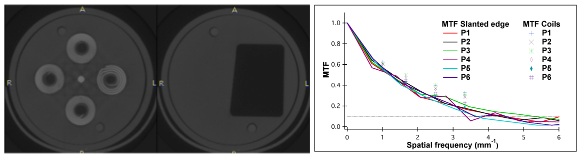

Figure 2: Resolution coils (left), slanted-edge (middle) sections and MTF (right) for all protocols measured from the slanted edge and resolution coil sections.

The QRM BarPattern phantom confirmed these results, as the smallest visible objects were those of 100 μm.

Geometric Accuracy: The geometric accuracy of the system was evaluated based on the reconstructed image of five beads placed at known distances. The nominal voxel spacing was within 0.1% of the manufacturer's specification.

Linearity: A highly linear relationship between measured CT number and iodine concentration was observed with a voltage dependent slope (Fig. 3). The same behavior was also observed for the CT number evaluation section for measured vs. expected CT number.

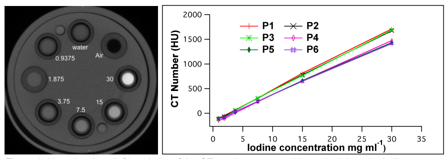

Figure 3: Linearity plate (left) and plot of the CT number measured in each vial vs. the iodine concentration.

Uniformity: The central region of the uniformity section always exhibited a lower CT number and a higher noise than peripheral regions. This cupping effect was masked by the noise (uniformity-to-noise ratio below 1) when the images were reconstructed except for protocols designed for low-noise (P5 and P6). At 50 μm voxel size, the noise was greatly increased and the uniformity-to-noise ratio decreased dramatically.

Contrast measurements: The CNR measured with the low contrast phantom was systematically lower than unity and decreased with the diameter and the contrast of the insert. The best contrast discrimination (highest CNR values) was observed for P2 and P5 protocols.

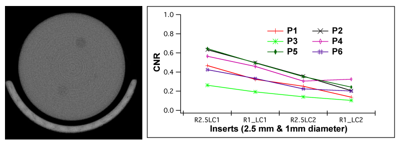

Figure 4: Low-contrast phantom (left) and CNR values measured for all low contrast inserts and for all protocols

SUMMARY

The eXplore CT 120 achieved a **mean resolution** in the range of **95-138 μm**. The system was shown to be linear and geometrically accurate. **The major difference between the scanning protocols was the noise level, which limits the detectability of low contrasts**. Further software developments including beam hardening and scatter corrections would make the scanner more promising.

REFERENCES

[1] L.Y. Du et al., Phys. Med. Biol. 52 (2007) 7087.

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