Musgrove Park Hospital

Characterising image quality for the Elekta XVI cone beam CT system: A local and multi-centre analysis

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Objective

The purpose of this study is to perform objective analysis to establish an image quality benchmark for the X-ray Volumetric Imaging (XVI) Cone Beam CT (CBCT) system (Elekta Oncology Systems, Crawley, UK) in use in our department and to compare this with other XVI systems in the South West region of the UK.

Materials and Methods

A Catphan 503 phantom (Fig. 1) from The Phantom Laboratory Inc., (Salem, USA) was imaged using the XVI (v4.5) and the resultant images analysed with the PIPSpro CBCT software (v4.2) from Standard Imaging (Middleton, USA).

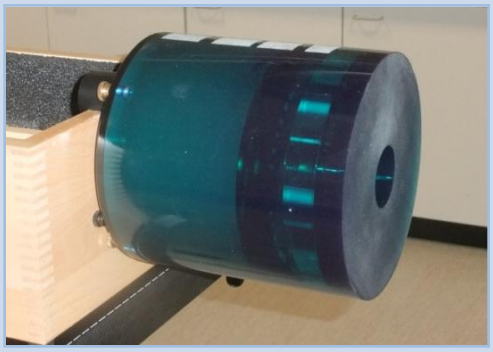

Figure 1 – The Catphan 503 phantom

A standard XVI preset was used with settings of 120kV, 40mA/frame and 40ms with collimator S20 and a small field of view. A full 360° scan was performed at a gantry speed of 180° per minute acquiring 660 frames. The projection image dimensions were 1024x1024 with the acquired volume scan. A high resolution reconstruction preset was used to reconstruct the data set using a voxel size of 0.5 mm and a reconstruction dimension of 540x520x540, downsizing the axial images to 512x512 as used clinically.

The local study assessed imaging consistency over time and determined the effects of changing mA per frame, kV and slice width.

The regional audit presents data from seven Elekta XVI systems at six different centres, measured using the same phantom, imaging presets, analysis software and operators.

Results

The software analysed three sections of the phantom (Fig. 2) and reported (a) the CT no. of inserts made of different materials, (b) spatial resolution, (c) uniformity, noise and low contrast information.

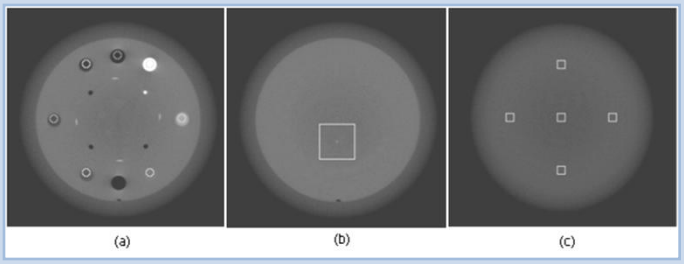

Figure 2 – Regions of analysis of the Catphan 503 phantom

Local measurements over a six month period showed the CT no. of the phantom and inserts were consistent to within ±10 HU (Fig. 3.a), apart from a minor discontinuity pre- and post- service in June 2011.

Spatial resolution was found to be 3.74 ±0.21, 6.28 ±0.27 and 7.98 ±0.57 cy/cm at the 50%, 10% and 2% levels respectively (Fig. 3.b).

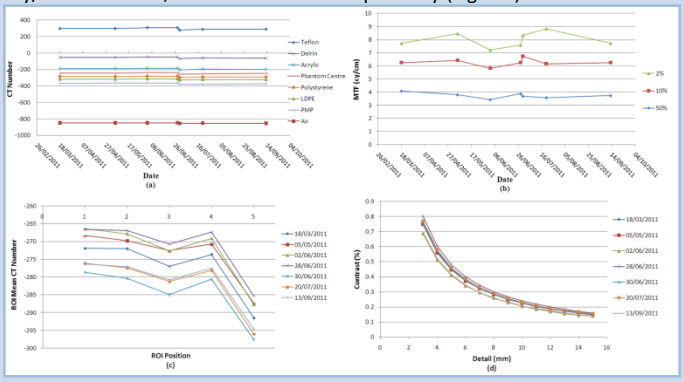

Figure 3 – Local consistency results

In the uniform module of the phantom, the reported CT numbers of the outer regions of interest (ROI) were radially consistent to approximately ±5 HU, with the central ROI consistently reported as 15-20 HU lower (Fig. 3.c), a phenomenon called the 'cupping effect'. Figure 3.d presents the percentage contrast required to delineate an object of stated dimension and these data were found to be consistent to within ±0.06% over the six month period.

Noise was found to increase with decreasing mA and kV, but the results are not presented here for reasons of brevity.

Within the regional audit, the XVI units were found to generally agree with each other (Figs. 4.a – 4.c), but with a spread in the reported CT nos. of about ±50 HU. A plot of mean CT no. at the centre of the central slice against the respective XVI acceptance date shows some correlation (Fig 4.d), suggesting performance degradation over time.

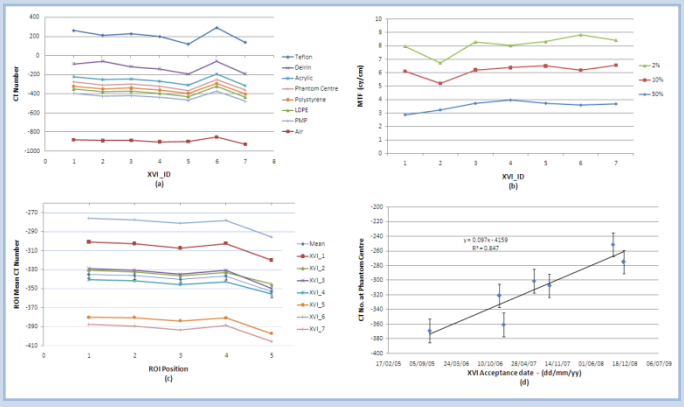

Figure 4 – Regional audit results.

Conclusions

The local XVI system gave consistent results over time.

The regional mini-audit revealed a spread in results, though all units exhibited similar patterns of behaviour and suggested a linear relationship between CT no. and the age of the XVI unit.

It was found that the Catphan 503 phantom and PIPSpro CBCT module are useful and effective tools to objectively analyse image quality.

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