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Development of a Quality Control phantom specifically designed for CBCT

Harry Charalabos Stamatakis1, Kostas Tsiklakis[1], Ruben Pauwels[2], Adrian Walker[3], Reinhilde Jacobs[2], Keith Horner[4], The SEDENTEXCT Project Consortium[5]

[1]Department of Oral Diagnosis and Radiology, Dental School, University of Athens, Greece
[2]Oral Imaging Centre, School of Dentistry, Catholic University of Leuven, Belgium
[3]Leeds Test Objects, Boroughbridge, UK
[4]School of Dentistry, University of Manchester, UK
[5]Listing of partners on www.sedentexct.eu

Objectives: To present the latest developments of a Quality Control (QC) phantom specifically designed for dental Cone Beam CT (CBCT).

Material-Methods: Two prototype phantoms were successively designed by Leeds Test Objects Ltd, UK, for tests on various CBCT units. The phantoms consist of a PMMA body and a number of inserts accommodating test objects for a number of image quality tests, including high and low contrast resolution, spatial resolution, pixel intensity values for dental tissues and bone densities, uniformity and noise, artifacts induction and geometric accuracy. Proper positioning and alignment was tested on different CBCT units with supine, standing or sitting patient configuration and different FOVs. The design of the prototype test inserts was evaluated by analyzing the resulted images from a number of different CBCT units.

Results: The earlier first prototype phantom required additional markings on the body for correct alignment of the test inserts, especially for units with limited Field of Views (FOV). Low contrast test inserts were found to be efficient, while high contrast test inserts needed modification in order to produce proper Line Spread Function (LSF) and Point Spread Function (PSF) curves. Spatial resolution test inserts needed to be redesigned, due to poor imaging of the test pattern and artifacts induction on several units. The latest second prototype phantom implements all required modifications. Positioning and test insert alignment is improved by additional visual markers, while guidance recesses on the test inserts ensure their fixed orientation in the phantom body. A new homogeneous PMMA section at the bottom of the phantom is added for uniformity and noise tests. Drilled holes in the PMMA body of the phantom instead of an insert are now used for geometric accuracy tests, further improving testing on units with large FOV. The new high contrast test inserts are found appropriate for producing MTF curves and the redesigned spatial resolution patterns are adequately visualized on the tested units. Artifact induction test inserts are now using lead in addition to titanium, as a high atomic number material.

Conclusions: The latest prototype phantom and test inserts are much improved than the earlier prototype. The modular design of the phantom with removable inserts is an important feature for use on units with small FOV. The redesigned inserts are now considered appropriate for the respective tests. Analysis of the QC phantom results will be further simplified for the end-user by employing the dedicated software tool for semi-automatic image quality analysis that is currently under development.

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