Insights into Imaging

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compositions and densities close to those of adipose and glandular tissues as described by Hammerstein (1979). A polymethylmethacrylate (PMMA) plate derived from the linearity insert of AAPM report 15 contains two series of iodinated zones with surface densities determined from clinical images. The first series covers these densities. Two areas of different equivalent glandularities and constant thickness overlap each half of these iodinated zones. The second series of constant iodine density is partially overlapped with a glandularity stepwedge (0-100%).
Results: Determined iodine densities are between 0.25 and 4 mg/cm^2. 1 cm glandular tissue is simulated with 0.09 cm HDPE and 0.94 cm water (error < 1%) and 1 cm adipose tissue with 0.64 cm HDPE and 0.31 cm water (error < 0.6%). Measurements in narrow beam conditions of image signal on a digital mammography system gave an average error of 5.8% vs. usual breast equivalent slabs (CIRS).
Conclusion: This method allows designing a phantom of iodine-injected breast adequate for image quality assessment of DE-CEDM. It is low cost and provides good flexibility for multiple thickness and glandularity configurations.

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Application of monochromatic images in artery stent assessment using CT spectral imaging: A phantom study

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Purpose: CT spectral imaging is capable of creating monochromic images so that high keV images with small beam hardening artifacts can be used for artery stent assessment. In this study, we compare the measured in-stent luminal diameter (ISLA) using monochromic images with the measured ISLA using 140 kVp image.
Methods and Materials: A coronary artery stent phantom (Cypher-2.5 mm) filled with contrast fluid and surrounded by water was scanned using a high definition CT in spectral imaging mode and the scan was repeated using 140 kVp in helical mode. Eleven monochromatic images (40 - 140 keV, 10 keV increment) and one 140 kVp image were reconstructed. The in-stent luminal diameter (ISLA) was measured as the full width half maximum (FWHM) of the attenuation profile across the stent at six different stent locations. The measured ISLA was then compared between the monochromic images and the140 kVp image using Mann-Whitney test.
Results: The accuracy of measured ISLA increased with the increase of keV in the monochromic images. For monochromic energy below 90 keV, the measured ISLA (40 keV: 46+2%; 50 keV: 47+2%; 60 keV: 48+2%; 70 keV: 48+2%; 80 keV: 49+2%) was found comparable to the measured value in the 140 kVp image (47±2%). For those at higher energies, statistical significantly ($p < 0.05$) better results were obtained (90 keV: 49+2%; 100 keV: 50+3%; 110 keV: 50+3%; 120 keV: 50+3%; 130 keV: 52+4%; 140 keV: 53+3%).
Conclusion: The accuracy of the artery stent assessment can be improved using high keV monochromic images in CT spectral imaging.

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Lesion detectability in digital mammography and digital breast tomosynthesis: A phantom study

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Purpose: The complexity of anatomical structure within the breast represents the ultimate limit to signal detection in a mammogram. To increase lesion conspicuity Digital Breast Tomosynthesis (DBT) has been recently proposed and several manufacturers are currently performing clinical trials. In this study, we have compared lesion detectability performance of digital mammography and DBT by making use of a phantom in which details of interest are within a heterogeneous background.
Methods and Materials: The breast phantom, CIRS (USA) model no. 020 BR3D, consists of various slabs made of heterogeneous tissue-equivalent material that exhibits characteristics of real breast tissue. Between these slabs, we have inserted thin layers of homogeneous material containing details of mammographic interest to simulate lesions. A commercial digital mammography unit and a DBT prototype, both manufactured by IMS (Italy), have been used for our study. The 3D reconstruction software is provided by Dexela (UK). 2D and 3D images of the breast phantom have been obtained at various dose levels to compare performance of the two modalities.
Results: Comparison between 2D and 3D images recorded at similar dose levels shows superior performance of DBT over digital mammography. Indeed, whilst certain details of interest are not detectable for any dose level with digital mammography, DBT can reveal their signal by reducing complexity of tissue structures.
Conclusion: This preliminary investigation demonstrates that in terms of physical image quality, the inherent limitations of 2D mammography due to structure noise can be overcome by the introduction of 3D reconstruction via breast tomosynthesis.

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Physical characterization of a novel wireless detector for digital radiography

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Purpose: Digital radiography (DR) technology has been the subject of great development to make the DR more suitable for clinical practice. One of the limiting factors of a DR system with respect to a computed radiography (CR) system was the inability to perform certain specific examinations due to the form factor of the DR detector. To address this problem, a novel wireless DR clinical system for general radiography has recently been introduced. The detector is based on indirect conversion using a Gadolinium-oxysulphide phosphor (Gd_2O_2S (Tb)). This unit, named DRX-1 (manufactured by Carestream Health), is based on a-Si:H photodiode and TFT technology. The goal of this work is to characterize the imaging performance of the device.
Methods and Materials: The physical characterization was measured in terms of performance metrics such as Modulation Transfer Function (MTF), Noise Power Spectra (NPS), Detective Quantum Efficiency (DQE), and contrast-detail (CD) analysis. The psychophysical characterization of the CD data was performed using custom evaluation software. The detector was tested under exposure to five different IEC specified beams: RQA 3, 5, 7, and 9.
Results: The measured MTF values were consistent with those reported for other phosphor based imaging systems (h_{50}~1.2 lp/mm). The DQE (0) values were respectively 25, 32, 33, and 25% for RQA 3, 5, 7, and 9. Contrast detail analysis results were comparable with results from a CsI DR under identical acquisition conditions.
Conclusion: The measured physical characteristics of DRX-1 are comparable with other digital imaging system widely used in clinical practice.

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Image quality performance evaluation of digital breast tomosynthesis on a GE senographe essential system

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Purpose: New methodologies are needed to provide measurements for image quality evaluation in digital tomosynthesis. We applied classical and novel methods to the comparison between a Senographe DS, previously used in clinical trials for tomosynthesis, and a Senographe Essential used in tomosynthesis mode.
Methods and Materials: Image quality in digital breast tomosynthesis (DBT) depends on acquisition parameters, detector performance, and reconstruction algorithms. Image quality measurement is done in projection views for DQE and in reconstructed DBT slices for quantum-limited performance and image uniformity (brightness, signal-to-noise, and resolution uniformity). Radiation quality using rhodium anode and filter at 30 kVp, typical of clinical use, was preferred over the normative molybdenum anode and filter at 28 kVp. New methods for evaluation of quantum-limited performance and image resolution uniformity are presented, and results from the new system are compared to those of the Senographe DS DBT system.
Results: The DQE of Senographe Essential in clinical tomosynthesis mode approaches 70% at 0.5 lp/mm and 8.7 µGy/view, substantially exceeding that of the Senographe DS. Quantum-limited operation is evaluated in the reconstructed volume, and Senographe Essential exhibits quantum-limited performance down to 8.7 µGy/view. Image brightness uniformity, SNR uniformity and resolution uniformity are on a par with the Senographe DS. Resolution uniformity measurements reveal the importance of proper sampling of the volume along the vertical axis.
Conclusion: The performance of the Senographe Essential in tomosynthesis mode is in line with expectations, offering similar image quality at 30% lower dose than Senographe DS.

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Performance assessment of dynamic spiral scan modes with variable pitch for quantitative perfusion computed tomography

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Purpose: Spatial coverage in dynamic contrast enhanced CT can be increased beyond the physical detector width using spiral scanning techniques with continuous periodic table movement and variable pitch (A4DS: adaptive 4D spiral). We compared perfusion values acquired with A4DS techniques with results from standard dynamic scans at different temporal sampling rates.
Methods and Materials: A biological perfusion phantom (preserved porcine kidney) was scanned with both techniques. In standard mode, three scans were performed at adjacent overlapping positions (detector width 38.4 mm) covering the whole phantom with temporal resolutions of 0.5, 1.0 and 1.5 s. The A4DS scans