

SPECT. It has been shown that interior problem, represented by the truncated Radon transform, has a null-space (and thus could theoretically have an artifact) containing any smooth function in the fully sampled field of view. In practice, artifacts tend to be smooth. Our purpose is to theoretically understand what artifacts will be typically generated under the interior problem. **Method and Materials:** A linear operator is constructed which generates members of the null-space of the internal Radon transform. A singular value decomposition of this operator is derived and the singular values are examined. **Results:** The singular values are all non-zero, confirming that the null-space of the truncated Radon transform contains all smooth functions. However, the singular values drop rapidly. When combined with the positivity constraint, this limits the magnitude of all but the lowest singular vectors. **Conclusion:** Although the null-space of the truncated Radon transform contains rapidly varying components, their amplitude will be exponentially small. This justifies the use of truncated images to quantitatively measure high-spatial-frequency objects such as organ boundaries. Although the formal null-space is infinite-dimensional, most of these dimensions are measured in practice with high accuracy. The artifacts generated from actual images can be described with high accuracy by only a few (2–10) parameters. Thus, supplements of the truncated data with low-quality non-truncated data or with simple priors can improve the quantifiable accuracy of truncated images.

SU-FF-I-74

A Modulation Transfer Function Comparison of Dual-Screen CR Systems

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Purpose: The goal of this study is to measure MTF of two dual-screen CR systems, and to explain the correlation between their system resolution and the physical properties of phosphor screens. **Method and Materials:** Modulation transfer function (MTF) is commonly used method to characterize the performance of an imaging system. The well-established edge method is used to quantify the MTF of digital radiographic systems. We use a sharply polished edge slanted with respect to sampling detector grid, which allows measurement of oversampled edge function profiles. The focus of this study is on the comparison of the presampled MTFs obtained for different thicknesses of phosphor screens and pixel sizes. MTFs were measured with both diagnostic and 6 MV x-rays. The storage phosphors used in this study were two commercially available CR plates: Kodak EC-L fast and Kodak EC-L regular cassettes. **Results:** The scan times per pixel for both high (0.171 mm) and low (0.342 mm) resolution are much shorter than 558 μ s of the dominant luminescence lifetime for Gd₂O₂S:Tb, used in this study. Consequently, the spatial resolution of KODAK 2000RT CR system is lower in the scan direction than in the moving direction due to the afterglow effect. A comparison of the MTFs with Kodak EC-L fast and regular cassettes indicates that the spatial resolution of dual-screen CR systems does not depend on the total thickness of phosphor screens but is determined by the thickness of the thicker phosphor screen in the dual-screen CR system. **Conclusion:** MTFs in laser scan direction roll off faster than in phosphor transport direction with KODAK 2000RT CR system. The resolution is related to the thickness of individual phosphors layers.

SU-FF-I-75

Noise Equivalent Quanta of CT Images: Results and Challenges

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Purpose: To evaluate changes in noise equivalent quanta (NEQ) as technique factors are varied in CT, and to evaluate NPS, MTF, and NEQ as standard quantitative metrics for CT image quality assessment. **Method and Materials:** The modulation transfer function [MTF(f)] of a GE lightspeed16, clinical CT scanner was measured. A 13 μ m, nickel-chromium wire was scanned at 120kVp and 400mAs to obtain a point spread function (PSF). Three reconstruction filters were evaluated. The measured PSF was integrated to obtain the line spread function (LSF), and the MTF(f) was then computed. Ten CT scans of a 20 cm diameter water-filled pipe were also acquired to measure the noise power spectra [NPS(f)] on the same scanner. The mAs was varied from 10 to 400mAs at constant kVp, and the kVp was varied from 80 to 140kVp at constant mAs. Images using each of the reconstruction filters were evaluated. Using N x N regions of interest (ROI) the NPS(f) was computed by calculating the 2D FFT of each ROI and

averaging all of the magnitude, squared FFT results. A minimum of 64 ROI were used per volume, and different ROI placement distributions were evaluated. The 2D results were averaged radially to obtain the 1D NPS(f). The NEQ(f) was computed by dividing the MTF²(f) by the NPS(f). **Results:** The MTF(f) measurement is straightforward and the NPS(f) metric for CT images demonstrates behavior consistent with trends in photon fluence and apodizing filter behavior. The NPS(f) and NEQ(f) curves demonstrated sensitive changes with kVp, mAs, and slice thickness. **Conclusion:** While NPS(f) and NEQ(f) normalization issues exist due to the normalization of CT images into Hounsfield Units, these metrics are sensitive to changes in technique and slice thickness changes and therefore are strong candidates for routine quantitative assessment of CT image quality.

SU-FF-I-76

Slot Scan Imaging Versus Anti-Scatter Grid Method in Digital Chest Imaging- a 4-AFC Study

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Purpose: To investigate and compare the anti-scatter grid and slot scanning methods for their effects on the observers' performance in digital chest imaging. **Materials and Methods:** Anthropomorphic chest phantom was imaged with an a-Si/a-Se flat-panel based digital radiography system. The system was operated in both the slot scanning and full-field modes. An anti-scatter grid was used. Imaging technique was 120 kVp and 0.15 to 16 mAs for both modes. After that, the grid was removed and same imaging technique was applied to acquire phantom images for both modes. 1-cm diameter computer-simulated nodule with a nominal peak contrast ratio of 5% was used to generate simulated nodules at hilum and sub-diaphragm locations by applying SPR values for all images. 4-AFC experiment was conducted to measure the ratio of correct observations as a function of the exposure level for various imaging conditions and locations. 24 sets of four-512x512 images were generated for each exposure level, resulting in generating 192 sets for each imaging condition and location. These images were displayed randomly on a review workstation. The ratios of correct observations versus exposure levels were computed for various imaging conditions and locations. **Result:** With low exposure, the observers' performance improved with the exposure level but reached the maximum at ~4 mAs for all techniques. At the hilum location, slot scan imaging without grid performed the best, followed by full-field imaging without grid. The use of an anti-scatter grid in both full-field and slot scan modes seemed to degrade the performance significantly. **Conclusion:** Improvement with the exposure level has been observed for all imaging techniques. However, the observers' performance reached the maximum at different rates depending on the nodule location and techniques.

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SU-FF-I-77

Relationship of Uncertainty in Pixel Intensity to Apparent Diffusion Coefficient Calculation

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Purpose: To estimate how variations in pixel uncertainty can affect calculations of Apparent Diffusion Coefficients (ADCs) used in therapy evaluation. **Methods and Materials:** ADCs are calculated for a Region of Interest (ROI) using Diffusion Weighted Magnetic Resonance Imaging (DWMRI). Uncertainties in pixel intensities, e.g. due to noise, are simulated by increasing or decreasing pixel intensities by $\pm 50\%$ from their nominal value. The large value (50%) of variation allows trends to be observed more easily. The resulting modified DWMRI images are then used to calculate ADC for ROIs, and the variation of the ADC as a function of position and/or slice number and/or ROI size is then observed. We have analyzed DWMRI scans for a number of patients. **Results:** Positive increases in pixel intensity result in lower ADC values and we hence observe the largest relative variation with this change. For the nominal ~300mm² ROI, with a +50% increase in pixel intensity, we see a maximum relative change of roughly a factor of six going from left to right (as the ROI crosses the ventricles) compared with a factor of three for the nominal pixel intensity. Similar changes were observed for inferior – superior positions (slice number). We see minimal or no variation in ADC Values as the area of the ROI is varied from 150 mm² to 600 mm². **Conclusion:** Positive variations in pixel uncertainty result in the largest variation of ADCs and

have the most effect in the region which has low average pixel intensity. This behavior is due to low Signal to Noise Ratio (SNR) in that region.

SU-FF-I-78

Evaluating the Effect of Dielectric Resonance On Image Uniformity at 1.5T and 3T in An ACR MRI Phantom Filled with Mineral Oil and Silicone Fluid

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Purpose: The use of oil-based phantoms instead of water-based ones is known to be a more suitable method of assessing image uniformity of high field magnets. This study aims to investigate the appropriateness of using oil or silicone in the ACR phantom for routine quality control for both 1.5T and 3T MRI systems paying particular attention to the dielectric resonance effect. **Methods and Materials:** A prototype ACR phantom which was used to help develop the existing ACR MRI phantom was filled with three different materials and scanned in both a 1.5T and 3T magnets using the recommended ACR T1 sequence. The first material was the standard phantom water-based liquid, the second material was mineral oil and the third was a silicone fluid. Percent image uniformity (PIU) as well as low and high contrast resolutions were assessed for all three filling liquids at both fields. **Results:** For the standard MRI phantom solution, the PIU was calculated to be 95% at 1.5 T and 80% at 3T. The same phantom filled with mineral oil produced a PIU of 99% on the 1.5 T and 95% on the 3T magnet. There was a marked decrease in SNR in going from standard aqueous solution to mineral oil, but this did not seem to affect the high contrast resolution or the low contrast detectability at either field. Results for the silicone fluid will also be presented. **Conclusions:** Central brightening artifacts are often seen as high signal intensity in the center of the imaged object and have caused problems with the PIU analysis of the water-based ACR phantom on 3T systems. Filling the phantom with a material that has a lower dielectric value than water such as mineral oil or silicone provides images which are more uniform and tends to improve the artifactual lower PIU measurements.

SU-FF-I-79

Evaluation of Reproducibility of fMRI Maps in Patients with Proven Low-Grade Brain Neoplasms

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Purpose: The focus of this project is to demonstrate the test re-test reliability of fMRI in subjects with benign and biopsy proven low-grade neoplasms. **Methods and Materials:** fMRI activation maps with different thresholds were generated for 6 subjects with benign and biopsy proven low-grade brain neoplasms using a GE Signa 1.5T MRI scanner and birdcage head coil. The imaging protocol included a 3D SPGR T1 brain volume, a coronal T2 anatomical acquisition (24 slices), and 8 functional scans. The 8 functional scans consisted of four functional task repeated twice. Each task verified one of the following: language, language comprehension, fine motor control, and visual perception with Blood Oxygen Dependent (BOLD) responses. Preprocessing steps included dicom to afni conversion, motion correction and spatial smoothing (9mm Gaussian filter). A correlation analysis was performed which allowed the reference timing of the BOLD response in the expected areas to be confirmed. A measure of reproducibility was calculated using the Euclidean distance between the center of mass of the activated volumes in two independent scans and measuring the number of reproducible activated voxels, R_{size} . **Results and Discussion:** Activated clusters were observed for each functional scan. Activated clusters were not observed in all subjects for each task. R_{size} was calculated to measure the reproducibility. These measurements will vary between 0.0 (worst) and 1.0 (best). The Text Listening Task provided the best reproducibility of activated clusters with an average value of 0.94 ± 0.05 and 0.90 ± 0.06 for the left and right temporal lobe, respectively. Activation of clusters amongst subjects varied greatly for the visual perception scan. Previous published results had similar findings. **Conclusions:** Similar comparisons of reproducibility will be made for more subjects. $R_{overlap}$, another parameter used for testing reproducibility will be calculated. The minimum number of clusters used and the cluster radius will be further examined to obtain more activated clusters.

SU-FF-I-80

Comparison of Artifact Size Caused by Metallic Tissue Marking Clips at 1.5T and 3T Breast MRI: A Phantom Study

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Purpose: To compare the signal void artifact size caused by metallic tissue marking clips at 1.5T and 3T and to test the impact of different readout bandwidth and TE on the artifact size. **Methods and Materials:** The signal void size of three commercially available metallic tissue marking clips were assessed at both 1.5T and 3T scanners. The clips studied were immersed in a gel phantom with enough distance ($>25\text{mm}$) to avoid field interference between them. An RF-spoiled T1-weighted gradient echo (SPGR) sequence commonly used in DCE breast imaging was used on both scanners with $TR/TE/FA=32/4.6/25^\circ$, $FOV=160\text{mm}$, spatial resolution of $1 \times 1 \times 4\text{mm}^3$, and water fat shift of 1.534 pixels (i.e., readout bandwidth = 22.6 kHz for 1.5T, and 45.3 kHz for 3T). Same sequence was repeated with higher readout bandwidth of 139 kHz (1.5T) and 198 kHz (3T). In addition, $TE=1.16\text{ms}$ was also tested with partial Fourier readout and high readout bandwidth to study change of TE on the effect of signal void artifact size on both scanners. **Results:** At $TE=4.6\text{ms}$, both scanners showed signal void artifacts 2~8 times larger than the clips themselves. Importantly, the signal void size was 15%~30% larger at 3T compared to that of 1.5T. Increasing readout bandwidth had little impact on signal void artifact size on both scanners. However, decreasing TE from 4.6 ms to 1.16 ms reduced the average artifact size at both 1.5T (27%) and 3T (31%). **Conclusion:** Signal void artifact size is larger at 3T for all three metallic tissue marking clips studied at the current experimental settings. This could be a disadvantage of 3T scanners when used to detect and follow-up breast cancer adjacent to metallic tissue marking clips after biopsy. Short TE can be used to effectively reduce signal void artifacts at both 1.5T and 3T.

SU-FF-I-81

3.0T fMRI Implementation for Surgical Planning in a Clinical Health Care Center

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Purpose: There has been lot of progress during past decade in blood oxygenation level dependent (BOLD) functional MRI (fMRI) and Diffusion Tensor Imaging (DTI). However their clinical use has not been available to many tertiary care centers because of lack of support in paradigm generation, presentation and post processing. Recently, technical advances in 3.0 T clinical MRI scanners, paradigm presentation/post processing, and available medical physics support have made fMRI achievable for clinical MRI settings. The purpose of this study is to utilize 3.0T fMRI study for clinical neurological surgical planning in a tertiary care setting. **Method and Materials:** All clinical fMRI are done on a 3.0 T GE Signa scanner using an 8 channel head coil. IFIS/Brainvoyager (MRI Devices) is used for paradigm development/presentations and analysis. Visual, verb generating, left/right motor, passive listening, rhyming, semantic paradigms/protocols are developed for clinical fMRI. Post processing of BOLD fMRI data on the scanner console (Brainwave) communicates with paradigm generating PC directly. Real-time BOLD fMRI post processing is done with Brainwave (GE Medical Systems). Additional post processing, including 3D rendering of functional activation mapping of the brain, are done on the scanner console using Brainwave, or Brainvoyager on a standalone workstation. DTI is acquired and post processed using Functool MR tractography (GE Medical Systems) for fiber tracking. **Results:** 15 clinical patients have been scanned using both BOLD fMRI and DTI for neurological surgical planning. Diagnostic results from 3.0T fMRI scan had significant impact on the planning of neurological procedures. **Conclusion:** Clinical fMRI at 3.0 T has been successfully implemented in a tertiary care center for neurological surgical planning. With the technical advances in clinical 3.0T scanner, paradigm software/hardware options, and medical physics support, fMRI is becoming robust and increasingly available for routine clinical use.

SU-FF-I-82

Noise Cancellation and Onset Detection of Verbal Responses During Functional Magnetic Resonance Imaging

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A method for scanner noise cancellation and detection of verbal responses during an fMRI experiment is presented. In recent fMRI experiments overt