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A safety approach of magnetic compatibility of metallic biomaterials in Magnetic Resonance Imaging

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Abstract

Interactions of metallic implants and monitoring devices with magnetic field must be an important safety consideration for both patients and staff in Magnetic Resonance Imaging. Metallic materials can be a contra-indication for MRI when it leads to safety issue (biohazards) or image misinterpretation (artefacts). Tests and safety guidelines are proposed concerning the MRI compatibility of non-active metallic materials. The evolution of laws concerning health and medical attitudes leads to set up standardized tests as a pre-requisite before marketing new medical implants or instruments. Furthermore, for not yet registered or miscellaneous materials, implanted or not, a clinical safety attitude is proposed and has to be respected by the MRI staff to detect and identify them in order to avoid potential accidents.

KEYWORDS: Magnetic Resonance Imaging, Metallic implants, Biohazards, Safety.

Monte Carlo (PENELOPE code) study of the x-ray beams from SL linacs (Elekta)

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Abstract

This study investigates the capabilities of the PENELOPE code for the simulation of three photon beams (6, 18 and 25 MV x-rays) from SL-Elekta medical linear accelerators (linacs). The radiation head has been separated in two parts, the target section and the collimator section. At the end of each section, phase space files containing all the particles and their parameters were stored. These generated files were validated according to a recent method [Med. Phys. 26 (8), 1999] already applied to EGS4 code. The sources of head scattered radiation have been identified and the proportion of contaminant electrons and positrons have been calculated for all the configuration beams. To check the validity of the photon beam descriptions, the characteristics (depth dose curves, cross profiles, output factors) have been determined for several field sizes ranging from 4x4 cm to 40x40 cm for a SSD of 100 cm and compared to measurements. Calculated linear attenuation coefficients in water for on axis and off axis positions (5, 10, 15 cm from beam axis) were compared to measured values. Primary and scatter dose separation in water was investigated, and the scattering functions and peak scatter factors for the studied field sizes have been evaluated. Incident electron mean energies on the target have been determined to 6, 17 and 21 MeV for 6, 18 and 25 MV x-ray beams respectively. The mean energy photon beam spectrum varies with field size by 26%, 33% and 18% for the three beam qualities between 4x4 cm and 40x40 cm square fields. Measured and calculated linear attenuation coefficients agree within 1.2%. Dose distributions in water and output factors are correlated with experimental values.

KEYWORDS: PENELOPE Monte Carlo code; SL linacs; Multileaf collimator (MLC); Output Factors; Primary and scatter doses.

Technical Note

Check on the use of thermoluminescence detectors for proton dose distribution measurements

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Abstract

The aim of this work is to investigate the use of thermoluminescent detectors in proton eye radiotherapy. These dosimeters have been used to measure beam characteristics such as the central axis depth-dose distributions and transverse profiles in unmodulated proton beams. The dosimetric features have been studied and will be reported in terms of their applications for in-vivo dosimetry and small irradiation field characterisation.

KEYWORDS: Protontherapy, TLD-100, Proton Dosimetry.

Technical Note

The effect of source step size and catheter separation for the dose non-uniformity ratio at single and double-plane high dose rate Ir-192 interstitial implants

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Abstract

The effect of the source step size and catheter separation on the dose uniformity within the volume of the implant was investigated at the most commonly used interstitial implant configurations (single plane, double-plane with square and triangular pattern) using high dose rate Ir-192 stepping source. The dose non-uniformity ratio (DNR) was plotted as a function of reference dose, then the minimum of the DNR and the dose at which this minimum occurs was determined. The former was found to be dependent on source step size, catheter separation and implant geometry, while the latter only on source step size and catheter separation. The most uniform dose distribution always occurred when the source step size was equal to 0.75 times the catheter separation.

KEYWORDS: Interstitial implants; Dose non-uniformity; High dose rate brachytherapy.

A mathematical model of thyroid mass reduction after radioiodine therapy of Graves' disease

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Abstract

Substantial reductions in the thyroid volume (up to 70-80%) after radioiodine therapy for Graves' hyperthyroidism are common and have been reported in the literature. However the effect of thyroid volume reduction on the calculation of the committed radiation dose has not been evaluated. In this paper a mathematical model of thyroid mass reduction during the clearance phase after ¹³¹I administration to patients affected by Graves' disease, is presented, demonstrating that the mass reduction of the gland in the first month after the therapy has a considerable effect on the calculated committed radiation dose.

It is assumed that thyroid volume reduction soon after therapy administration is linearly correlated with the specific activity in the gland. This can be expressed by a differential equation that can be easily solved assuming a monoexponential clearance function for the iodine in thyroid. The solution $m(t)$ gives the change in thyroid mass during the first month after therapy, and depends on the maximum activity in thyroid, on the effective half-time, on the mass of the gland before the therapy and on the individual's rate of change in thyroid mass over time.

A set of measurements of thyroid volume was made by ultrasonography (7.5 MHz probe) on twenty-nine patients affected by Graves' disease. The measurements were made before and after ¹³¹I treatment, during the iodine clearance phase. The experimental data were fitted with the equation $m(t)$ and demonstrated good agreement with the proposed model. Doses calculated considering the change in mass were as much as 25% different than those calculated using traditional methods (i.e not considering a variable thyroid mass).

The mathematical model of thyroid mass reduction is in good agreement with our experimental data. It is very simple and can be used to provide the reduction of thyroid mass during the first month after the therapy using parameters that can be easily evaluated. The model should be used in the algorithms for the calculation of the radiation committed dose to the thyroid. A worksheet for the calculation of the committed dose and for the evaluation of the reduction of the mass of the thyroid is also presented. This worksheet is very simple to use. It can help physicians in the evaluation of mass changes and cumulative absorbed dose in ¹³¹I therapy of the Graves' disease.

KEYWORDS: Thyroid dosimetry, Thyroid volume reduction, Graves' disease

Conference Paper

Recent advances in CT: Will doses go down or will they go up?*

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Manuscript received: May 12, 2000, revised: July 28, 2000

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Abstract

Driven by the introduction of spiral scanning techniques, CT technology and CT applications have provided great advances in the past decade. The use of CT in general has increased strongly, in direct contradiction to the expectations in the late eighties that CT would be replaced by MR. What does this mean for the dose to the patient?

It is to be expected that cumulative doses will go up as the frequency of examinations increases. This is not the topic of this presentation, however. This paper will discuss the dose to the individual patient for a complete examination as a function of scanning technique, scanner technology and special dose reduction efforts.

It has been accepted that spiral CT itself does not cause an increase in dose, but that it offers efficient means for dose reduction with no compromise in image quality. The dependency on kVp, mAs, filtration etc. remain basically unaltered and are independent of the scan mode. The newly introduced multi-row detector technology for multi-slice acquisitions does not change this situation fundamentally, but dose efficiency is affected to some degree in practical implementations. A particularly interesting new aspect is given by tube current modulation and retrospective adaptive filtering techniques with a potential for dose reduction of more than 50%. We conclude that individual patient doses in CT should go down with proper equipment and procedures. This can definitely be assured by modern equipment and by appropriate educational measures and regulatory efforts.

KEY WORDS: Dose, CT, spiral CT.

Conference Paper

Trend Analysis of Measurements of CT Numbers over a Prolonged Period *

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Abstract

The results of periodic performance tests of the reproducibility of CT numbers are presented, and implications for the validity of the quality criteria set on this parameter by different professional groups are discussed. Results are presented for a 12 year period on 13 CT scanners in East Anglian hospitals. They confirm the theoretical prediction that it is not appropriate to set a single criterion for reproducibility across the full range of CT numbers. With modern equipment the CT number should remain within ± 5 Hounsfield Units or $\pm 5\%$ of the baseline value, whichever is the greater. Meeting these criteria will assist in demonstrating that image quality is being maintained and will also ensure acceptable precision for radiotherapy treatment planning.

KEYWORDS: CT Number, Reproducibility, Performance Tests, Quality Criteria.

Conference Paper

Dose in multi-slice spiral CT

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Abstract

In order to reduce patient dose in CT imaging while maintaining diagnostic image quality, the total detective quantum efficiency (DQE) of the CT system, which is a direct measure of the image quality per applied radiation dose, must be optimized.

In this paper we discuss the benefits of the *Siemens UFC* scintillator for fast CT imaging and the advantages of the adaptive array detector design implemented in the *Siemens Volume Zoom* multi-slice CT scanner, both improving the DQE significantly in comparison to other materials and designs. We present data showing that the *Volume Zoom* multi-slice CT has a dose efficiency similar to a single-slice CT scanner. Dose and pixel noise are independent of pitch and collimation width. This allows the user to have full control over the applied dose while maintaining high flexibility in the choice of pitch, collimation width and reconstructed slice width according to the requirements of the clinical situation.

KEYWORDS: Multi-slice spiral CT, CT radiation dose, CT image quality, detective quantum efficiency.

Conference Paper

Tomographic imaging with synchrotron radiation *

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Abstract

The SYRMEP collaboration is developing a tomographic imaging project with synchrotron radiation in the energy range 15-35 keV, using a photostimulable phosphor image plate and a high efficiency silicon pixel detector. We present here the preliminary studies which have been carried out in order to define the optimum working parameters and to evaluate the performances of the whole system. Simulation programs have been developed to determine the required angular resolution of the alignment system, and to select the optimal energy to visualize mammographic details while delivering the minimum dose. Images of custom test objects have been acquired in order to evaluate the spatial and contrast resolution of the two detectors. The delivered dose is comparable to the dose delivered in conventional planar mammography.

KEYWORDS: computed tomography, mammography, synchrotron radiation.

Conference Paper

Development of a small-field quasi-monochromatic computer tomography system*

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Abstract

The diagnostic potentiality of x-ray tomography could be very useful to improve the performance of Single Photon Emission Tomography by means of the fusion of morphological images with functional ones. Moreover an improvement in image-quality and a reduction in patient dose of CT imager could be achieved by means of monochromatic (or quasi-monochromatic) x-ray beams. Narrow-energy-band and tunable sources are ideal for CT because they can improve the image quality by overcoming the beam hardening effect and can reduce the dose delivered to the patient by selecting the more suitable energy.

Several monochromatic CT experiments have been performed so far using synchrotron radiation. Because of the cost and size of synchrotron facilities, the development of new technologies for monochromatic x-ray CT is desirable. To this aim, we have performed experiments to verify if a Bragg diffraction based x-ray source can be used in x-ray CT. Small field CT images of test object and biological samples have been obtained. Image uniformity, contrast resolution and spatial resolution have been evaluated.

KEYWORDS: CT, monochromatic beams, Bragg diffraction.

Conference Paper

Actual situation of implementation of EC-Directive 97/43/Euratom [MED] in Europe*

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Abstract

The actual situation of implementation of the EC-Directive 97/43/Euratom [MED] in Europe was investigated. A questionnaire was therefore sent by e-mail to all EFOMP members electronic accessible. The preliminary results were presented during the EFOMP workshop preceding the ECR 2000 in Vienna. From the 30 members electronic accessible 23 responded being 77%. In this paper the questions and answers are presented. Amongst the 23 responders 13 were from European Union members (EUM). Before the end of 2000 all EUM respondents expect to have the EC directive 97/43/Euratom implemented in their national legislation. Nearly all responding EUM do have a state recognition of the Medical Physicist in their country. The main problems encountered are lack of financial resources, the official recognition of the system for continuous professional development (CPD) and the implementation of the directive in Diagnostic Radiology. It became clear that there is no universally accepted term for a Medical Physics Expert.

KEY WORDS: EC Directive, Medical Physics Expert.

Conference Paper

Opportunities and Challenges for Medical Physicists in the new European Union “Medical Exposures” Directive*

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Abstract

A new Council Directive from the European Union has set out revised guidelines on health protection of individuals against the dangers of ionising radiation in relation to medical exposure. This paper summarises the ways in which the Directive is likely to change the role of physics in diagnostic radiology and discusses some of the opportunities and challenges that this provides for medical physicists.

KEY WORDS: Diagnostic radiology; EFOMP; patient protection.