A correlation study of eye lens dose and personal dose equivalent for interventional cardiologists

This paper presents the dosimetry part of the European ELDO project, funded by the DoReMi Network of Excellence, in which a method was developed to estimate cumulative eye lens doses for past practices based on personal dose equivalent values, $H_p(10)$, measured above the lead apron at several positions at the collar, chest and waist levels. Measurement campaigns on anthropomorphic phantoms were carried out in typical interventional settings considering different tube projections and configurations, beam energies and filtration, operator positions and access routes and using both mono-tube and biplane X-ray systems. Measurements showed that eye lens dose correlates best with $H_p(10)$ measured on the left side of the phantom at the level of the collar, although this correlation implicates high spreads (41 %). Nonetheless, for retrospective dose assessment, $H_p(10)$ records are often the only option for eye dose estimates and the typically used chest left whole-body dose measurement remains useful.

General information

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Organisations: Prostate cancer research center (PCRC), IRSN Institut de Radioprotection et de Surete Nucleaire, Nuclear Research Centre, Greek Atomic Energy Commission, Federal Office for Radiation Protection, STUK - Radiation and Nuclear Safety Authority
Contributors: Farah, J., Struelens, L., Dabin, J., Koukorava, C., Donadille, L., Jacob, S., Schnelzer, M., Auvinen, A., Vanhavere, F., Clairand, I.
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Source: Scopus
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A mathematical model and iterative inversion for fluorescent optical projection tomography

Solving the fluorophore distribution in a tomographic setting has been difficult because of the lack of physically meaningful and computationally applicable propagation models. This study concentrates on the direct modelling of fluorescence signals in optical projection tomography (OPT), and on the corresponding inverse problem. The reconstruction problem is solved using emission projections corresponding to a series of rotational imaging positions of the sample. Similarly to the bright field OPT bearing resemblance with the transmission x-ray computed tomography, the fluorescent mode OPT is analogous to x-ray fluorescence tomography (XFCT). As an improved direct model for the fluorescent OPT, we derive a weighted Radon transform based on the XFCT literature. Moreover, we propose a simple and fast iteration scheme for the slice-wise reconstruction of the sample. The developed methods are applied in both numerical experiments and inversion of fluorescent OPT data from a zebrafish embryo. The results demonstrate the importance of propagation modelling and our analysis provides a flexible modelling framework for fluorescent OPT that can easily be modified to adapt to different imaging setups.

General information

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Organisations: Computing Sciences, BioMediTech, Research group: Computational Biophysics and Imaging Group, Champalimaud Foundation
Contributors: Koljonen, V., Koskela, O., Montonen, T., Rezaei, A., Belay, B., Figueiras, E., Hyttinen, J., Pursiainen, S.
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Source: Scopus
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A Mixed Finite Element Method to Solve the EEG Forward Problem

Finite element methods have been shown to achieve high accuracies in numerically solving the EEG forward problem and they enable the realistic modeling of complex geometries and important conductive features such as anisotropic conductivities. To date, most of the presented approaches rely on the same underlying formulation, the continuous Galerkin (CG)-FEM. In this article, a novel approach to solve the EEG forward problem based on a mixed finite element method (Mixed-FEM) is introduced. To obtain the Mixed-FEM formulation, the electric current is introduced as an additional unknown besides the electric potential. As a consequence of this derivation, the Mixed-FEM is, by construction, current preserving, in contrast to the CG-FEM. Consequently, a higher simulation accuracy can be achieved in certain scenarios, e.g., when the diameter of thin insulating structures, such as the skull, is in the range of the mesh resolution. A theoretical derivation of the Mixed-FEM approach for EEG forward simulations is presented, and the algorithms implemented for solving the resulting equation systems are described. Subsequently, first evaluations in both sphere and realistic head models are presented, and the results are compared to previously introduced CG-FEM approaches. Additional visualizations are shown to illustrate the current preserving property of the Mixed-FEM. Based on these results, it is concluded that the newly presented Mixed-FEM can at least complement and in some scenarios even outperform the established CG-FEM approaches, which motivates a further evaluation of the Mixed-FEM for applications in bioelectromagnetism.

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Organisations: Mathematics, Research group: Inverse Problems, University of Utah, Cluster of Excellence EXC, University of Münster
Contributors: Vorwerk, J., Engwer, C., Pursiainen, S., Wolters, C. H.
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A model to estimate the outcome of prostate cancer photodynamic therapy with TOOKAD soluble WST11

Interstitial photodynamic therapy is becoming an interesting modality to treat some early stage prostate cancers. A light-sensitive drug is injected to the patient and activated by light using optical fibres inserted inside the prostate. In this work, we were interested in the characterization of the light action model for the WST11 (Tookad Soluble) drug. A retrospective analysis was performed on results from 28 patients enrolled in phase I and II trials with the WST11 drug. A drug dose of 4 mg/kg patient, dose light of 200 J cm^{-1} and wavelength of 753 nm were used. Correlation between the illuminated volume and the obtained necrosis, measured at day 7 MR images, was clearly established. This result suggests that photodynamic therapy planning is possible based on this model.

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Organisations: Frontier Photonics, Lille University Hospital - CHRU, Univ Paris 06, Centre National de la Recherche Scientifique (CNRS), Pierre & Marie Curie University - Paris 6, Institut de Recherche pour le Developpement (IRD), Inria, Institut National de la Sante et de la Recherche Medicale (Inserm), Univ Sorbonne, CNRS,ICM,UMR S 1127,UMR 7225,U1127, INSERM,Inria Paris Rocquencourt,Inst Cerveau & Mo, Univ Lille Nord de France
Contributors: Betrouni, N., Lopes, R., Puech, P., Colin, P., Mordon, S.
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Source: Scopus
Source ID: 79961059627
Research output: Contribution to journal › Article › Scientific › peer-review

Application of the ELDO approach to assess cumulative eye lens doses for interventional cardiologists

In preparation of a large European epidemiological study on the relation between eye lens dose and the occurrence of lens opacities, the European ELDO project focused on the development of practical methods to estimate retrospectively cumulative eye lens dose for interventional medical professionals exposed to radiation. The present paper applies one of the ELDO approaches, correlating eye lens dose to whole-body doses, to assess cumulative eye lens dose for 14 different Finnish interventional cardiologists for whom annual whole-body dose records were available for their entire working period. The estimated cumulative left and right eye lens dose ranged from 8 to 264 mSv and 6 to 225 mSv, respectively. In addition, calculations showed annual eye lens doses sometimes exceeding the new ICRP annual limit of 20 mSv. The work also highlights the large uncertainties associated with the application of such an approach proving the need for dedicated dosimetry systems in the routine monitoring of the eye lens dose.

General information

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Organisations: Prostate cancer research center (PCRC), Institut de Radioprotection et de Sû reté Nucléaire (IRSN) - PRP-HOM/SDE, Nuclear Research Centre, STUK - Radiation and Nuclear Safety Authority, Greek Atomic Energy Commission , Federal Office for Radiation Protection
Contributors: Farah, J., Struelens, L., Auvinen, A., Jacob, S., Koukorava, C., Schnelzer, M., Vanhavere, F., Clairand, I.
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Research output: Contribution to journal › Article › Scientific › peer-review

Complete electrode model in EEG: Relationship and differences to the point electrode model
In electroencephalography (EEG) source analysis, a primary current density generated by the neural activity of the brain is reconstructed from external electrode voltage measurements. This paper focuses on accurate and effective simulations of EEG through the complete electrode model (CEM). The CEM allows for the incorporation of the electrode size, shape and effective contact impedance into the forward simulation. Both neural currents in the brain and shunting currents between the electrodes and the skin can affect the measured voltages in the CEM. The goal of this study was to investigate the CEM by comparing it with the point electrode model (PEM), which is the current standard electrode model for EEG. We used a three-dimensional, realistic and high-resolution finite element head model as the reference computational domain in the comparison. The PEM could be formulated as a limit of the CEM, in which the effective impedance of each electrode goes to infinity and the size tends to zero. Numerical results concerning the forward and inverse errors and electrode voltage strengths with different impedances and electrode sizes are presented. Based on the results obtained, limits for extremely high and low impedance values of the shunting currents are suggested.

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Organisations: Mathematical modelling with wide societal impact (MathImpact), Aalto University, University of Münster
Contributors: Pursiainen, S., Lucka, F., Wolters, C. H.
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Research output: Contribution to journal › Article › Scientific › peer-review

Computed tomography of the parathyroids: The value of density measurements to distinguish between parathyroid adenomas of the lymph nodes and the thyroid parenchyma

Purpose: To compare the densities of parathyroid adenomas, lymph nodes and the thyroid parenchyma during multi-phase cervico-thoracic computed tomography to determine the differentiating threshold values. Materials and methods: This study comprises 30 patients operated for a parathyroid adenoma after computed tomography without injection and then 45 and 70 seconds after the injection of an iodine based contrast product (350 mgI/mL, 150 mL, 3 mL/s). The density of the adenomas, lymph nodes and thyroid was measured during the three phases (D0, D45, D70). The relative enhancement (RE) at 45 seconds was calculated: RE = (D45-D0)/D0. Results: A significant difference was found in the spontaneous density of the parathyroid adenomas of the thyroid (P <0.01) with a threshold value of 75 HU. A significant difference is found in the enhancement after injection of the adenomas and lymph nodes (P <0.01). The adenomas present an enhancement peak at 45 seconds while the maximum enhancement of the lymph nodes is at 70 seconds. At 45 seconds, a threshold value of 114 HU and an RE 125% allows them to be distinguished (sensitivity and specificity 0.96). Conclusion: Measurement of the densities can differentiate between the parathyroid adenomas, lymph nodes and thyroid.

General information

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Contributors: Marmin, C., Toledano, M., Lemaire, S., Boury, S., Mordon, S., Ernst, O.
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Original language: English
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Source: Scopus
Source ID: 84871875821
Research output: Contribution to journal › Article › Scientific › peer-review

CT and MRI imaging at the acute phase of inaugural non-traumatic hepatic haemorrhages

Purpose: Although rare, non-traumatic hepatic haemorrhage is a known complication of liver tumors. In cases where the haemorrhage is the first clinical event, diagnostic work-up is critical. Material and methods: This retrospective study was conducted between July 2001 and March 2011. Acute phase CT-scan and MRI imaging in patients diagnosed with non-traumatic liver hematomas were interpreted with particular attention to the radio-semiotic characteristics of hematomas and liver lesions. Those findings were then confronted to the patients' final diagnoses. Results: Twelve patients were included (mean age of 42 years). In seven of them a suspect liver lesion was discovered in the acute CT-Scan or MRI imaging. All lesions were strongly hyper vascular.The haemorrhage revealed hepatocarcinoma in four patients, liver adenoma in two and focal nodular hyperplasia in an other. Conclusion: It is important in spontaneous liver haemorrhage to consider the high probability of hepatocarcinoma or potentially malignant lesions even when the patient has no known hepatic disorders, and especially in young patients. The results of this study show that imaging is a key issue at the acute phase of inaugural non-traumatic hepatic haemorrhages and requires a simple but complete triphasic injected protocol.

General information

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Contributors: Boulouis, G., Marmin, C., Lemaire, S., Boury, S., Sergent, G., Mordon, S., Ernst, O.
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Source: Scopus
Source ID: 84878201644
Research output: Contribution to journal › Article › Scientific › peer-review

Diffusion tensor imaging of the cervical spinal cord in healthy adult population: Normative values and measurement reproducibility at 3t mri
Background: Compared to diffusion tensor imaging (DTI) of the brain, there is a paucity of reports addressing the applicability of DTI in the evaluation of the spinal cord. Most normative data of cervical spinal cord DTI consist of relatively small and arbitrarily collected populations. Comprehensive normative data are necessary for clinical decisionmaking. Purpose: To establish normal values for cervical spinal cord DTI metrics with region of interest (ROI)- and fiber tractography (FT)-based measurements and to assess the reproducibility of both measurement methods. Material and Methods: Forty healthy adults underwent cervical spinal cord 3T MRI. Sagittal and axial conventional T2 sequences and DTI in the axial plane were performed. Whole cord fractional anisotropy (FA) and apparent diffusion coefficient (ADC) values were determined at different cervical levels from C2 to C7 using the ROI method. DTI metrics (FA, axial, and radial diffusivities based on eigenvalues λ1, λ2, and λ3, and ADC) of the lateral and posterior funicles were measured at C3 level. FA and ADC of the whole cord and the lateral and posterior funicles were also measured using quantitative tractography. Intra- and inter-observer variation of the measurement methods were assessed. Results: Whole cord FA values decreased and ADC values increased in the rostral to caudal direction from C2 to C7. Between the individual white matter funicles no statistically significant difference for FA or ADC values was found. Both axial diffusivity and radial diffusivity of both lateral funicles differed significantly from those of the posterior funicle. Neither gender nor age correlated with any of the DTI metrics. Intra-observer variation of the measurements for whole cord FA and ADC showed almost perfect agreement with both ROI and tractography-based measurements. There was more variation in measurements of individual columns. Inter-observer agreement varied from moderate to strong for whole cord FA and ADC. Conclusion: Both ROI- and FT-based measurements are applicable methods yielding reproducible results for cervical spinal cord DTI metrics. Normative values for both measurement methods are presented.

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Organisations: Integrated Technologies for Tissue Engineering Research (ITTE), Tampere University Hospital, Department of Radiology, Pirkanmaan sairaanhoitopiiri
Contributors: Brander, A., Koskinen, E., Luoto, T. M., Hakulinen, U., Helminen, M., Savilahti, S., Ryymin, P., Dastidar, P., Öhman, J.
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Research output: Contribution to journal › Article › Scientific › peer-review

Electroencephalographic signals during anesthesia recorded from surface and depth electrodes

Purpose: Anesthesiologists have increasingly started to use EEG-based indexes to estimate the level and type of unconsciousness. However, the physiology and biophysics are poorly understood in anesthesiological literature. Methods: EEG was recorded from electrodes on the surface of head, including scalp, as well as DBS (deep brain stimulation) electrodes implanted deep in the brain. Mathematical modeling with a realistic head model was performed to create illustrative images of the sensitivity of electrode montages. Results: EEG pattern of anesthesia, burst-suppression, is recordable outside of scalp area as well in the depth of brain because the EEG current loops produce recordable voltage gradients in the whole head. The typical electrodes used in anesthesia monitoring are most sensitive to basal surface of frontal lobes as well as frontal and mesial parts of temporal lobes. Conclusions: EEG currents create closed-loops, which flow from the surface of the cortex and then return to the inside of the hemispheres. In the case of widespread synchronous activity like physiological sleep or anesthesia, the currents recorded with surface and depth electrodes return through the base of brain and skull.

General information

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Organisations: Faculty of Biomedical Sciences and Engineering, Central Hospital of Seinäjoki, Tampere University Hospital, Aalto University, Oulu University Hospital
Contributors: Jäntti, V., Ylinen, T., Subramaniyam, N. P., Kamata, K., Yli-Hankala, A., Kauppinen, P., Sonkajärvi, E.
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Keywords: anesthesia, EEG, electrode, montage, sensitivity
DOIs:

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EXT="Subramaniyam, Narayan Puthanmadam"
Source: Scopus
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Evaluation of overall setup accuracy and adequate setup margins in pelvic image-guided radiotherapy: Comparison of the male and female patients

We evaluated adequate setup margins for the radiotherapy (RT) of pelvic tumors based on overall position errors of bony landmarks. We also estimated the difference in setup accuracy between the male and female patients. Finally, we compared the patient rotation for 2 immobilization devices. The study cohort included consecutive 64 male and 64 female patients. Altogether, 1794 orthogonal setup images were analyzed. Observer-related deviation in image matching and the effect of patient rotation were explicitly determined. Overall systematic and random errors were calculated in 3 orthogonal directions. Anisotropic setup margins were evaluated based on residual errors after weekly image guidance. The van Herk formula was used to calculate the margins. Overall, 100 patients were immobilized with a house-made device. The patient rotation was compared against 28 patients immobilized with CIVCO's Kneefix and Feetfix. We found that the usually applied isotropic setup margin of 8. mm covered all the uncertainties related to patient setup for most RT treatments of the pelvis. However, margins of even 10.3. mm were needed for the female patients with very large pelvic target volumes centered either in the symphysis or in the sacrum containing both of these structures. This was because the effect of rotation ($p \leq 0.02$) and the observer variation in image matching ($p \leq 0.04$) were significantly larger for the female patients than for the male patients. Even with daily image guidance, the required margins remained larger for the women. Patient rotations were largest about the lateral axes. The difference between the required margins was only 1. mm for the 2

immobilization devices. The largest component of overall systematic position error came from patient rotation. This emphasizes the need for rotation correction. Overall, larger position errors and setup margins were observed for the female patients with pelvic cancer than for the male patients.

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Organisations: Integrated Technologies for Tissue Engineering Research (ITTE), Tampere University Hospital, Department of Oncology, Department of Medical Physics
Contributors: Laaksomaa, M., Kapanen, M., Tulijoki, T., Peltola, S., Hyödynmaa, S., Kellokumpu-Lehtinen, P. L.
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Source ID: 84893640829
Research output: Contribution to journal › Article › Scientific › peer-review

Focal Laser Ablation of Prostate Cancer: Numerical Simulation of Temperature and Damage Distribution
Background: The use of minimally invasive ablative techniques in the management of patients with low grade and localized prostate tumours could represent a treatment option between active surveillance and radical therapy. Focal laser ablation (FLA) could be one of these treatment modalities. Dosimetry planning and conformation of the treated area to the tumor remain major issues, especially when, several fibers are required. An effective method to perform pre-treatment planning of this therapy is computer simulation. In this study we present an in vivo validation of a mathematical model.Methods: The simulation model is based on finite elements method (FEM) to solve the bio-heat and the thermal damage equations. Laser irradiation was performed with a 980 nm laser diode system (5 W, 75 s). Light was transmitted using a cylindrical diffusing fiber inserted inside a preclinical animal prostate cancer model induced in Copenhagen rats. Non-enhanced T2-weighted and dynamic gadolinium-enhanced T1-weighted MR imaging examinations were performed at baseline and 48 hours after the procedure. The model was validated by comparing the simulated necrosis volume to the results obtained in vivo on (MRI) and by histological analysis. 3 iso-damage temperatures were considered 43° C, 45° C and 50° C.Results: The mean volume of the tissue necrosis, estimated from the histological analyses was 0.974 ± 0.059 cc and 0.98 ± 0.052 cc on the 48 h MR images. For the simulation model, volumes were: 1.38 cc when T = 43° C, 1.1 cc for T = 45°C and 0.99 cc when T = 50 C°.Conclusions: In this study, a clear correlation was established between simulation and in vivo experiments of FLA for prostate cancer.Simulation is a promising planning technique for this therapy. It needs further more evaluation to allow to FLA to become a widely applied surgical method.

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Organisations: Frontier Photonics, Univ Lille Nord de France, Lille University Hospital - CHRU, Inserm (French National Institute of Health and Medical Research), National Institutes of Health, Bethesda
Contributors: Marqa, M. F., Colin, P., Nevoux, P., Mordon, S. R., Betrouni, N.
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ASJC Scopus subject areas: Biomedical Engineering, Radiological and Ultrasound Technology, Radiology Nuclear Medicine and imaging, Biomaterials
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Functional brain segmentation using inter-subject correlation in fMRI

The human brain continuously processes massive amounts of rich sensory information. To better understand such highly complex brain processes, modern neuroimaging studies are increasingly utilizing experimental setups that better mimic daily-life situations. A new exploratory data-analysis approach, functional segmentation inter-subject correlation analysis (FuSeISC), was proposed to facilitate the analysis of functional magnetic resonance (fMRI) data sets collected in these experiments. The method provides a new type of functional segmentation of brain areas, not only characterizing areas that display similar processing across subjects but also areas in which processing across subjects is highly variable. FuSeISC was tested using fMRI data sets collected during traditional block-design stimuli (37 subjects) as well as naturalistic auditory narratives (19 subjects). The method identified spatially local and/or bilaterally symmetric clusters in several cortical areas, many of which are known to be processing the types of stimuli used in the experiments. The method is not only useful for spatial exploration of large fMRI data sets obtained using naturalistic stimuli, but also has other potential applications, such as generation of a functional brain atlases including both lower- and higher-order processing areas. Finally, as a part of FuSeISC, a criterion-based sparsification of the shared nearest-neighbor graph was proposed for detecting clusters in noisy data. In the tests with synthetic data, this technique was superior to well-known clustering methods, such as Ward's method, affinity propagation, and K-means ++. Hum Brain Mapp 38:2643–2665, 2017.

General information

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MoE publication type: A1 Journal article-refereed
Organisations: Signal Processing, Department of Mathematical Information Technology, Jyväskylän yliopisto, University of Helsinki, VTT Technical Research Centre of Finland, Aalto University, AI Virtanen Institute for Molecular Sciences, Ita-Suomen yliopisto
Contributors: Kauppi, J., Pajula, J., Niemi, J., Hari, R., Tohka, J.
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Publication date: 1 May 2017
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Publication information

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Volume: 38
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ISSN (Print): 1065-9471
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Scopus rating (2017): CiteScore 9.5 SJR 2.664 SNIP 1.413
Original language: English
ASJC Scopus subject areas: Anatomy, Radiological and Ultrasound Technology, Radiology Nuclear Medicine and imaging , Neurology, Clinical Neurology
Keywords: functional magnetic resonance imaging, functional segmentation, Gaussian mixture model, human brain, inter-subject correlation, inter-subject variability, naturalistic stimulation, shared nearest-neighbor graph
DOIs:

10.1002/hbm.23549

Bibliographical note

EXT="Kauppi, Jukka-Pekka"
INT=sgn,"Niemi, Jari"
EXT="Tohka, Jussi"
Source: Scopus
Source ID: 85015094854
Research output: Contribution to journal › Article › Scientific › peer-review

Iron overload of hematological origin: validation of a screening procedure for cardiac overload by MRI in routine clinical practice.

Screening for cardiac iron overload is generally done by magnetic resonance imaging (MRI) and demonstrated by a shortening of the myocardial T2* below 20 ms at 1.5 Tesla. This measurement was validated with a specific sequence and the CMRTools(®) calculation software (reference technique). The objective of this study was to validate the use of sequences and software programs that are available in routine clinical practice to screen for iron overload. First, a phantom of 11 tubes with a T2* between 4 and 33 ms was tested at three sites that had MRI machines of different brands. Second, the myocardial T2* values of 75 patients were measured in routine clinical practice using two methods. The first method used the reference sequence specially installed in the machines associated with the CMRTool software. The second method used the standard acquisition sequences available in the machines followed by calculation on a computer spreadsheet. In the phantom, the mean of the differences in T2* between each machine was 0.6 ms. Thirteen patients had a lowered T2* value with the reference technique. Three cases were poorly classified using the routine technique and corresponded with false positives of low overload (T2* between 18 and 20 ms). Screening for myocardial iron overload can be done by MRI by using sequences and calculation software available in routine clinical practice during the same examination as the one for the evaluation of hepatic iron overload.

General information

Publication status: Published
MoE publication type: A1 Journal article-refereed
Organisations: Frontier Photonics, Lille University Hospital - CHRU
Contributors: Ernst, O., Thuret, I., Petit, P., Ameur, F., Loundou, A. D., de Kerviler, E., Izzillo, R., Willig, A. L., Pascal, L., Verlhac, S., Mordon, S., Fenaux, P., Rose, C.
Number of pages: 8
Pages: 601-608
Publication date: Jun 2013
Peer-reviewed: Yes

Publication information

Journal: Diagnostic and interventional imaging
Volume: 94
Issue number: 6
Ratings:

Scopus rating (2013): CiteScore 0.5 SJR 0.193 SNIP 0.377
Original language: English
ASJC Scopus subject areas: Radiological and Ultrasound Technology, Medicine(all), Radiology Nuclear Medicine and imaging
URLs:

http://www.scopus.com/inward/record.url?scp=84895848508&partnerID=8YFLogxK (Link to publication in Scopus)
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Source ID: 84895848508
Research output: Contribution to journal › Article › Scientific › peer-review

Lead field theory provides a powerful tool for designing microelectrode array impedance measurements for biological cell detection and observation

Background: Our aim is to introduce a method to enhance the design process of microelectrode array (MEA) based electric bioimpedance measurement systems for improved detection and viability assessment of living cells and tissues. We propose the application of electromagnetic lead field theory and reciprocity for MEA design and measurement result interpretation. Further, we simulated impedance spectroscopy (IS) with two- and four-electrode setups and a biological cell to illustrate the tool in the assessment of the capabilities of given MEA electrode constellations for detecting cells on or in the vicinity of the microelectrodes. Results: The results show the power of the lead field theory in electromagnetic simulations of cell-microelectrode systems depicting the fundamental differences of two- and four-electrode IS measurement configurations to detect cells. Accordingly, the use in MEA system design is demonstrated by assessing the differences between the two- and four-electrode IS configurations. Further, our results show how cells affect the lead fields in these MEA system, and how we can utilize the differences of the two- and four-electrode setups in cell detection. The COMSOL simulator model is provided freely in public domain as open source. Conclusions: Lead field theory can be successfully applied in MEA design for the IS based assessment of biological cells providing the necessary visualization and insight for MEA design. The proposed method is expected to enhance the design and usability of automated cell and tissue manipulation systems required for bioreactors, which are intended for the automated production of cell and tissue grafts for medical purposes. MEA systems are also intended for toxicology to assess the effects of chemicals on living cells. Our results demonstrate that lead field concept is expected to enhance also the development of such methods and devices.

General information

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MoE publication type: A1 Journal article-refereed
Organisations: Faculty of Biomedical Sciences and Engineering, Research group: Computational Biophysics and Imaging Group, BioMediTech, Institute of Biomedical Engineering and Informatics
Contributors: Böttrich, M., Tanskanen, J. M., Hyttinen, J. A.
Publication date: 26 Jun 2017
Peer-reviewed: Yes

Publication information
Journal: BioMedical Engineering Online
Volume: 16
Issue number: 1
Article number: 85
ISSN (Print): 1475-925X
Ratings:

Scopus rating (2017): CiteScore 3.6 SJR 0.542 SNIP 1.027
Original language: English
ASJC Scopus subject areas: Radiological and Ultrasound Technology, Biomaterials, Biomedical Engineering, Radiology Nuclear Medicine and imaging
Keywords: Bioimpedance, Biological cells, Finite element analysis, Impedance spectroscopy, Microelectrodes, Sensor arrays
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full paper
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Source: Scopus
Source ID: 85021204612
Research output: Contribution to journal › Article › Scientific › peer-review

Long-term MRI findings of patients with embolized cerebral aneurysms
Background: Long-term follow-up studies after endovascular treatment for intracranial aneurysm are still rare and inconclusive. Parenchymal infarctions related to aneurysms have mostly been studied in patients with subarachnoidal hemorrhage (SAH) but infarction rates in patients with endovascularly treated unruptured aneurysms have been little studied. Purpose: To determine the frequency of permanent parenchymal lesions as detected in magnetic resonance imaging (MRI) in patients treated with endovascular coiling and to assess aneurysm-related infarctions after the initial treatment period. Material and Methods: A total of 64 patients (32 with primarily ruptured aneurysms) with 69 embolized aneurysms were examined neurologically and by MRI and magnetic resonance angiography (MRA) more than 9 years after the initial endovascular treatment. Results: A total of 14 out of 32 (44%) SAH patients and 11 (34%) patients with unruptured aneurysms had parenchymal lesions in MRI. Infarctions were detected in 10 (31%) SAH patients and the majority (9/10, 90%) of them were aneurysm-related. All aneurysm-related infarctions were detected at the acute hospitalization stage. A total of six (55%) out of 11 infarctions in patients with unruptured aneurysms were aneurysm-related and two of them appeared after the treatment period. Patients with infarction had poorer clinical outcome than patients with no ischemic lesions in MRI. Conclusion: Nineteen percent of patients with unruptured and 41% with ruptured aneurysms had aneurysmrelated parenchymal lesions in MRI. Most of these were detected during acute treatment period. Aneurysmrelated infarctions after treatment period are uncommon.

General information
Publication status: Published
MoE publication type: A1 Journal article-refereed
Organisations: Integrated Technologies for Tissue Engineering Research (ITTE), Tampere University Hospital, Medical Imaging Center
Contributors: Pyysalo, L. M., Keski-Nisula, L. H., Niskakangas, T. T., Kähärä, V. J., Öhman, J. E.
Number of pages: 7
Pages: 204-210
Publication date: Mar 2011
Peer-reviewed: Yes

Publication information
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Volume: 52
Issue number: 2
ISSN (Print): 0284-1851
Ratings:

Scopus rating (2011): CiteScore 2.5 SJR 0.728 SNIP 0.811
Original language: English
ASJC Scopus subject areas: Radiology Nuclear Medicine and imaging, Radiological and Ultrasound Technology
Keywords: Aneurysms, CNS, Embolization, Interventional, MR imaging
DOIs:

10.1258/ar.2010.100127
URLs:

http://www.scopus.com/inward/record.url?scp=79958827960&partnerID=8YFLogxK (Link to publication in Scopus)
Source: Scopus
Source ID: 79958827960
Research output: Contribution to journal › Article › Scientific › peer-review

Mathematical modelling of the action potential of human embryonic stem cell derived cardiomyocytes

Background: Human embryonic stem cell derived cardiomyocytes (hESC-CMs) hold high potential for basic and applied cardiovascular research. The development of a reliable simulation platform able to mimic the functional properties of hESC-CMs would be of considerable value to perform preliminary test complementing in vitro experimentations.Methods: We developed the first computational model of hESC-CM action potential by integrating our original electrophysiological recordings of transient-outward, funny, and sodium-calcium exchanger currents and data derived from literature on sodium, calcium and potassium currents in hESC-CMs.Results: The model is able to reproduce basal electrophysiological properties of hESC-CMs at 15 40 days of differentiation (Early stage). Moreover, the model reproduces the modifications occurring through the transition from Early to Late developmental stage (50-110, days of differentiation). After simulated blockade of ionic channels and pumps of the sarcoplasmic reticulum, Ca^{2+} transient amplitude was decreased by 12% and 33% in Early and Late stage, respectively, suggesting a growing contribution of a functional reticulum during maturation. Finally, as a proof of concept, we tested the effects induced by prototypical channel blockers, namely E4031 and nickel, and their qualitative reproduction by the model.Conclusions: This study provides a novel modelling tool that may serve useful to investigate physiological properties of hESC-CMs.

General information

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MoE publication type: A1 Journal article-refereed
Organisations: Integrated Technologies for Tissue Engineering Research (ITTE), Biomedical Engineering Laboratory - D.E.I.S, University of Bologna, CNR-INO, University of Geneva
Contributors: Paci, M., Sartiani, L., Del Lungo, M., Jaconi, M., Mugelli, A., Cerbai, E., Severi, S.
Publication date: 28 Aug 2012
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Journal: BioMedical Engineering Online
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Article number: 61
ISSN (Print): 1475-925X
Ratings:

Scopus rating (2012): CiteScore 2.8 SJR 0.467 SNIP 1.191
Original language: English
ASJC Scopus subject areas: Biomedical Engineering, Radiological and Ultrasound Technology, Radiology Nuclear Medicine and imaging, Biomaterials
Keywords: Action potential, Computer simulation, Embryonic stem cells, Pharmacology
DOIs:

10.1186/1475-925X-11-61
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Source: Scopus
Source ID: 84865344484
Research output: Contribution to journal › Article › Scientific › peer-review

Method for Simulating Dose Reduction in Digital Breast Tomosynthesis

This work proposes a new method of simulating dose reduction in digital breast tomosynthesis (DBT), starting from a clinical image acquired with a standard radiation dose. It considers both signal-dependent quantum and signal-independent electronic noise. Furthermore, the method accounts for pixel crosstalk, which causes the noise to be frequency-dependent, thus increasing the simulation accuracy. For an objective assessment, simulated and real images were compared in terms of noise standard deviation, signal-to-noise ratio (SNR) and normalized noise power spectrum (NNPS). A two-alternative forced-choice (2-AFC) study investigated the similarity between the noise strength of low-dose simulated and real images. Six experienced medical physics specialists participated on the study, with a total of 2,160 readings. Objective assessment showed no relevant trends with the simulated noise. The relative error in the standard

deviation of the simulated noise was less than 2% for every projection angle. The relative error of the SNR was less than 1.5%, and the NNPS of the simulated images had errors less than 2.5%. The 2-AFC human observer experiment yielded no statistically significant difference (p=0.84) in the perceived noise strength between simulated and real images. Furthermore, the observer study also allowed the estimation of a dose difference at which the observer perceived a just-noticeable difference (JND) in noise levels. The estimated JND value indicated that a change of 17% in the current-time product was sufficient to cause a noticeable difference in noise levels. The observed high accuracy, along with the flexible calibration, make this method an attractive tool for clinical image-based simulations of dose reduction.

General information
Publication status: Published
MoE publication type: A1 Journal article-refereed
Organisations: Signal Processing, Research group: Signal and Image Restoration-RST
Contributors: Borges, L. R., Guerrero, I., Bakic, P. R., Foi, A., Maidment, A. D., Vieira, M. A.
Pages: 2331-2342
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Journal: IEEE Transactions on Medical Imaging
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Scopus rating (2017): CiteScore 9.3 SJR 1.895 SNIP 2.904
Original language: English
ASJC Scopus subject areas: Software, Radiological and Ultrasound Technology, Computer Science Applications, Electrical and Electronic Engineering
Keywords: Biomedical imaging, Breast, Calibration, digital breast tomosynthesis, dose reduction, Electronic noise, Estimation, Image reconstruction, quantum noise, Signal to noise ratio, Standards
Electronic versions:

Borges-DBT_Sim-TMI2017
DOIs:

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URLs:

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Source: Scopus
Source ID: 85023177059
Research output: Contribution to journal › Article › Scientific › peer-review

MR image texture in Parkinson's disease: A longitudinal study
Background: Few of the structural changes caused by Parkinson's disease (PD) are visible in magnetic resonance imaging (MRI) with visual inspection but there is a need for a method capable of observing the changes beyond the human eye. Texture analysis offers a technique that enables the quantification of the image gray-level patterns. Purpose: To investigate the value of quantitative image texture analysis method in diagnosis and follow-up of PD patients. Material and Methods: Twenty-six PD patients underwent MRI at baseline and after 2 years of follow-up. Four co-occurrence matrix-based texture parameters, describing the image homogeneity and complexity, were calculated within clinically interesting areas of the brain. In addition, correlations with clinical characteristics (Unified Parkinson's Disease Ranking Scales I-III and Mini-Mental State Examination score) along with a comparison to healthy controls were evaluated. Results: Patients at baseline and healthy volunteers differed in their brain MR image textures mostly in the areas of substantia nigra pars compacta, dentate nucleus, and basilar pons. During the 2-year follow-up of the patients, textural differences appeared mainly in thalamus and corona radiata. Texture parameters in all the above mentioned areas were also found to be significantly related to clinical scores describing the severity of PD. Conclusion: Texture analysis offers a quantitative method for detecting structural changes in brain MR images. However, the protocol and repeatability of the method must be enhanced before possible clinical use.

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MoE publication type: A1 Journal article-refereed
Organisations: Department of Electronics and Communications Engineering, Integrated Technologies for Tissue Engineering Research (ITTE), University of Tampere, Medical School, Tampere University Hospital, Medical Imaging Center and Hospital Pharmacy, Department of Neurology and Rehabilitation, Department of Radiology
Contributors: Sikiö, M., Holli-Helenius, K. K., Harrison, L. C. V., Ryymin, P., Ruottinen, H., Saunamäki, T., Eskola, H. J., Elovaara, I., Dastidar, P.
Number of pages: 8

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ISSN (Print): 0284-1851
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Original language: English
ASJC Scopus subject areas: Radiology Nuclear Medicine and imaging, Radiological and Ultrasound Technology, Medicine(all)
Keywords: Follow-up, Image analysis, Magnetic resonance imaging (MRI), Parkinson's disease, Texture analysis
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Contribution: organisation=elt,FACT1=1
Portfolio EDEND: 2014-08-20
Publisher name: Sage Publications
Source: researchoutputwizard
Source ID: 1506
Research output: Contribution to journal › Article › Scientific › peer-review

Randomized Multiresolution Scanning in Focal and Fast E/MEG Sensing of Brain Activity with a Variable Depth
We focus on electro-/magnetoencephalography imaging of the neural activity and, in particular, finding a robust estimate for the primary current distribution via the hierarchical Bayesian model (HBM). Our aim is to develop a reasonably fast maximum a posteriori (MAP) estimation technique which would be applicable for both superficial and deep areas without specific a priori knowledge of the number or location of the activity. To enable source distinguishability for any depth, we introduce a randomized multiresolution scanning (RAMUS) approach in which the MAP estimate of the brain activity is varied during the reconstruction process. RAMUS aims to provide a robust and accurate imaging outcome for the whole brain, while maintaining the computational cost on an appropriate level. The inverse gamma (IG) distribution is applied as the primary hyperprior in order to achieve an optimal performance for the deep part of the brain. In this proof-of-the-concept study, we consider the detection of simultaneous thalamic and somatosensory activity via numerically simulated data modeling the 14-20 ms post-stimulus somatosensory evoked potential and field response to electrical wrist stimulation. Both a spherical and realistic model are utilized to analyze the source reconstruction discrepancies. In the numerically examined case, RAMUS was observed to enhance the visibility of deep components and also marginalizing the random effects of the discretization and optimization without a remarkable computation cost. A robust and accurate MAP estimate for the primary current density was obtained in both superficial and deep parts of the brain.

General information
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MoE publication type: A1 Journal article-refereed
Organisations: Computing Sciences, Research group: Inverse Problems
Contributors: Rezaei, A., Koulouri, A., Pursiainen, S.
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Peer-reviewed: Yes

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Journal: Brain Topography
Volume: 33
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ISSN (Print): 0896-0267
Original language: English
ASJC Scopus subject areas: Anatomy, Radiological and Ultrasound Technology, Radiology Nuclear Medicine and imaging , Neurology, Clinical Neurology
Keywords: Brain imaging, Depth reconstruction, EEG and MEG data, Hierarchical Bayesian model, Randomized multiresolution scanning
Electronic versions:

Randomized Multiresolution Scanning in Focal 2020

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http://urn.fi/URN:NBN:fi:tuni-202006256224
Source: Scopus
Source ID: 85079741204
Research output: Contribution to journal › Article › Scientific › peer-review

Simple estimation of induced electric fields in nervous system tissues for human exposure to non-uniform electric fields at power frequency

Most results regarding induced current in the human body related to electric field dosimetry have been calculated under uniform field conditions. We have found in previous work that a contact current is a more suitable way to evaluate induced electric fields, even in the case of exposure to non-uniform fields. If the relationship between induced currents and external non-uniform fields can be understood, induced electric fields in nervous system tissues may be able to be estimated from measurements of ambient non-uniform fields. In the present paper, we numerically calculated the induced electric fields and currents in a human model by considering non-uniform fields based on distortion by a cubic conductor under an unperturbed electric field of 1 kV m^{-1} at 60 Hz. We investigated the relationship between a non-uniform external electric field with no human present and the induced current through the neck, and the relationship between the current through the neck and the induced electric fields in nervous system tissues such as the brain, heart, and spinal cord. The results showed that the current through the neck can be formulated by means of an external electric field at the central position of the human head, and the distance between the conductor and the human model. As expected, there is a strong correlation between the current through the neck and the induced electric fields in the nervous system tissues. The combination of these relationships indicates that induced electric fields in these tissues can be estimated solely by measurements of the external field at a point and the distance from the conductor.

General information
Publication status: Published
MoE publication type: A1 Journal article-refereed
Organisations: Department of Electronics and Communications Engineering, Research group: Environmental Health, National Institute of Technology, Kagawa College, University of Miyazaki, Tokushima University
Contributors: Tarao, H., Miyamoto, H., Korpinen, L., Hayashi, N., Isaka, K.
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Journal: Physics in Medicine and Biology
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Issue number: 12
ISSN (Print): 0031-9155
Ratings:
Scopus rating (2016): CiteScore 5.3 SJR 1.381 SNIP 1.442
Original language: English
ASJC Scopus subject areas: Radiology Nuclear Medicine and imaging, Radiological and Ultrasound Technology
Keywords: brain, cubic conductor, induced current through the neck, Numerical human model, spinal cord
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URLs:
http://urn.fi/URN:NBN:fi:tty-201607254336

Bibliographical note
EXT="Tarao, Hiroo"
Source: Scopus
Source ID: 84975045682
Research output: Contribution to journal › Article › Scientific › peer-review

Simulation of developing human neuronal cell networks

Background: Microelectrode array (MEA) is a widely used technique to study for example the functional properties of neuronal networks derived from human embryonic stem cells (hESC-NN). With hESC-NN, we can investigate the earliest developmental stages of neuronal network formation in the human brain. Methods: In this paper, we propose an in silico model of maturating hESC-NNs based on a phenomenological model called INEX. We focus on simulations of the

development of bursts in hESC-NNs, which are the main feature of neuronal activation patterns. The model was developed with data from developing hESC-NN recordings on MEAs which showed increase in the neuronal activity during the investigated six measurement time points in the experimental and simulated data. Results: Our simulations suggest that the maturation process of hESC-NN, resulting in the formation of bursts, can be explained by the development of synapses. Moreover, spike and burst rate both decreased at the last measurement time point suggesting a pruning of synapses as the weak ones are removed. Conclusions: To conclude, our model reflects the assumption that the interaction between excitatory and inhibitory neurons during the maturation of a neuronal network and the spontaneous emergence of bursts are due to increased connectivity caused by the forming of new synapses.

General information
Publication status: Published
MoE publication type: A1 Journal article-refereed
Organisations: Department of Electronics and Communications Engineering, BioMediTech, Faculty of Engineering and Computer Science, School of Management (JKK)
Contributors: Lenk, K., Priwitzer, B., Ylä-Outinen, L., Tietz, L. H. B., Narkilahti, S., Hyttinen, J. A.
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ASJC Scopus subject areas: Radiological and Ultrasound Technology, Biomaterials, Biomedical Engineering, Radiology Nuclear Medicine and imaging
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Simulation of developing human neuronal cell networks
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Bibliographical note
EXT="Ylä-Outinen, Laura"
Source: Scopus
Source ID: 84984652694
Research output: Contribution to journal › Article › Scientific › peer-review

Spinal cord injury induces widespread chronic changes in cerebral white matter
Traumatic spinal cord injuries (SCIs) lead to axonal damage at the trauma site, as well as disconnections within the central nervous system. While the exact mechanisms of the long-term pathophysiological consequences of SCIs are not fully understood, it is known that neuronal damage and degeneration are not limited to the direct proximity of the trauma. Instead, the effects can be detected even in the cerebrum. We examined SCI-induced chronic brain changes with a case-control design using 32 patients and 70 control subjects. Whole-brain white matter (WM) tracts were assessed with diffusion tensor imaging (DTI). In addition, we analysed associations between DTI metrics and several clinical SCI variables. Whole-brain analyses were executed by tract-based spatial statistics (TBSS), with an additional complementary atlas-based analysis (ABA). We observed widespread, statistically significant ($P \leq 0.01$) changes similar to neural degeneration in SCI patients, both in the corticospinal tract (CST) and beyond. In addition, associations between DTI metrics and time since injury were found with TBSS and ABA, implying possible long-term post-injury neural regeneration. Using the ABA approach, we observed a correlation between SCI severity and DTI metrics, indicating a decrease in WM integrity along with patient sensory or motor scores. Our results suggest a widespread neurodegenerative effect of SCI within the cerebrum that is not limited to the motor pathways. Furthermore, DTI-measured WM integrity of chronic SCI patients seemed to improve as time elapsed since injury.

General information
Publication status: Published
MoE publication type: A1 Journal article-refereed
Organisations: BioMediTech, Faculty of Biomedical Sciences and Engineering, Research group: Quantitative medical imaging, Pirkanmaan sairaanhoitopiiri
Contributors: Ilvesmäki, T., Koskinen, E., Brander, A., Luoto, T., Öhman, J., Eskola, H.

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Journal: Human Brain Mapping
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Original language: English
ASJC Scopus subject areas: Anatomy, Radiological and Ultrasound Technology, Radiology Nuclear Medicine and imaging , Neurology, Clinical Neurology
Keywords: Cerebrum, Diffusion tensor imaging, Humans, Spinal cord injuries, White matter
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Source ID: 85018637972
Research output: Contribution to journal › Article › Scientific › peer-review

Wound healing of human embryonic stem cell-derived retinal pigment epithelial cells is affected by maturation stage
Background: Wound healing of retinal pigment epithelium (RPE) is a complex process that may take place in common age-related macular degeneration eye disease. The purpose of this study was to evaluate whether wounding and wound healing has an effect on Ca^{2+} dynamics in human embryonic stem cell (hESC)-RPEs cultured different periods of time. Methods: The 9-day-cultured or 28-day-cultured hESC-RPEs from two different cell lines were wounded and the dynamics of spontaneous and mechanically induced intracellular Ca^{2+} activity was measured with live-cell Ca^{2+} imaging either immediately or 7days after wounding. The healing time and speed were analyzed with time-lapse bright field microscopy. The Ca^{2+} activity and healing speed were analysed with image analysis. In addition the extracellular matrix deposition was assessed with confocal microscopy. Results: The Ca^{2+} dynamics in hESC-RPE monolayers differed depending on the culture time: 9-day-cultured cells had higher number of cells with spontaneous Ca^{2+} activity close to freshly wounded edge compared to control areas, whereas in 28-day-cultured cells there was no difference in wounded and control areas. The 28-day-cultured, wounded and 7-day-healed hESC-RPEs produced wide-spreading intercellular Ca^{2+} waves upon mechanical stimulation, while in controls propagation was restricted. Most importantly, both wave spreading and spontaneous Ca^{2+} activity of cells within the healed area, as well as the cell morphology of 28-day-cultured, wounded and thereafter 7-day-healed areas resembled the 9-day-cultured hESC-RPEs. Conclusions: This acquired knowledge about Ca^{2+} dynamics of wounded hESC-RPE monolayers is important for understanding the dynamics of RPE wound healing, and could offer a reliable functionality test for RPE cells. The data presented in here suggests that assessment of Ca^{2+} dynamics analysed with image analysis could be used as a reliable non-invasive functionality test for RPE cells.

General information
Publication status: Published
MoE publication type: A1 Journal article-refereed
Organisations: Faculty of Biomedical Sciences and Engineering, Research group: Computational Biophysics and Imaging Group, University of Eastern Finland, University Central Hospital Kuopio
Contributors: Abu Khamidakh, A. E., Rodriguez-Martinez, A., Kaarniranta, K., Kallioniemi, A., Skottman, H., Hyttinen, J., Juuti-Uusitalo, K.
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Article number: 102
ISSN (Print): 1475-925X
Ratings:

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Original language: English
ASJC Scopus subject areas: Radiological and Ultrasound Technology, Biomaterials, Biomedical Engineering, Radiology Nuclear Medicine and imaging
Keywords: Ca waves, Cell maturation, HESC-RPE, Image analysis, Mechanical stimulation, Mechanically induced intercellular Ca waves, RPE, Spontaneous [Ca] increases, Wound healing
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Research output: Contribution to journal › Article › Scientific › peer-review