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<tr>
<th>Plasma 1</th>
<th>Overcoming Limitations of Virtual Observation Points in pTx using IMPULSE</th>
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<td>Miri Parmeister(^1) and Brian K Rutt(^1)</td>
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<td>(^1)Stanford University, Stanford, CA, United States</td>
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We analyze the performance of the IMPULSE pTx optimization algorithm, which allows SAR-aware pulse design without virtual observation points (VOP) compression. We compare performance of IMPULSE with conventional optimization methods using VOPs and compare different values of the overestimation parameter. We show that IMPULSE results in elimination of the time-intensive compression step without significantly increasing the time for real-time optimization. Additionally by eliminating the overestimation error from the VOP compression, IMPULSE is able to achieve better mitigation of local SAR hotspots after optimization than VOP-based methods.

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<th>Plasma 2</th>
<th>Optical-based probe for real time assessment of RF electrical field during MRI exam</th>
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<td>Isabelle Saniour(^1), Gwenaël Gaborit(^2,3), Lionel Duchillaret(^4), Anne-Laure Perrier(^5), and Olivier Beuff(^6)</td>
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<td>(^1)Univ. Lyon, CREATIS ; CNRS UMR 5220 ; INSERM U1206 ; INSA-Lyon ; UJ-M-Saint-Etienne ; Université Lyon1, Villeurbanne, France, (^2)Univ. Savoie-Mont-Blanc, IMEP-LAHC, Le Bourget-du-Lac, France, (^3)Kapteos, Sainte-Hélène-du-Lac, France</td>
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During MRI exam, Specific Absorption Rate (SAR) is essential to be controlled and can be evaluated by measuring either indirectly for instance the rise in temperature or directly the radiofrequency induced electrical \(E\)-field. In the current study, we proposed an optical probe based on the Pockels effect for subcentimeter resolution measurements of the \(E\)-field without altering the surrounding media. Measurements were performed at 4.7 T and 3.0 T. Results show that the probe has an excellent linear response and allow a real time estimate of the three components of the \(E\)-field produced during MRI examination.

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<th>Plasma 3</th>
<th>Modeling of Peripheral Nervous Stimulation Thresholds in Realistic Body Models</th>
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<td>Mathias Davids(^1,2), Bastien Guérin(^2,3), Lothar R Schad(^4), and Lawrence L Wald(^1,4)</td>
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<td>(^1)Computer Assisted Clinical Medicine, Heidelberg University, Mannheim, Germany, (^2)Martinos Center for Biomedical Imaging, Massachusetts General Hospital, Charlestown, MA, USA, (^3)Harvard Medical School, Boston, MA, USA, (^4)Harvard-MIT Division of Health Sciences Technology, Cambridge, United States</td>
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Peripheral Nervous Stimulation (PNS) has become an important limitation in MRI with the latest generation of high-performance gradient systems. We present – to our knowledge for the first time – a model to predict PNS thresholds for arbitrary coil geometries. Our model consists of an accurate body model for EM simulations, a detailed nerve atlas of the human body, and a numerical model to predict nerve responses to induced electrical fields. With this model, we were able to reproduce PNS threshold curves of two leg/arm solenoid coils that were previously evaluated experimentally. We intent to use this PNS model to design high-performance gradient coils with significantly lowered PNS capabilities.

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<th>Plasma 4</th>
<th>Cardiac Synchronization at Ultra-High Field Using a 3-Lead ECG Trigger Device</th>
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<td>Daniel Stäb(^1), Juergen Roessler(^3), Kieran O’Brien(^2), Je Yen Su(^4), Christian Hamilton-Craig(^4), and Markus Barth(^4)</td>
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<td>(^1)The Centre for Advanced Imaging, The University of Queensland, Brisbane, Australia, (^2)Siemens Healthcare GmbH, Erlangen, Germany, (^3)Siemens Healthcare Pty Ltd, Brisbane, Australia, (^4)Richard Slaughter Centre of Excellence in CVMRI, The Prince Charles Hospital, Brisbane, Australia</td>
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Accurate cardiac synchronization is essential in CMR. At ultra-high field, ECG triggering can be significantly impacted by the magneto-hydrodynamic (MHD) effect. Here, we investigate the performance of a conventional 3-lead ECG trigger device and a state-of-the-art trigger algorithm for cardiac ECG synchronization at 7 T. We show that by appropriate subject preparation and by including a learning phase for the R-wave detection outside of the magnetic field, reliable ECG triggering at ultra-high field is feasible despite severe distortions of the ECG signal. A quantitative analysis in 10 healthy subjects revealed a trigger sensitivity and specificity of 97.6% and 98.4%, respectively.

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<th>Plasma 5</th>
<th>A Combined 7 Tesla MRI/NMR Probe Head for Photochemical Applications</th>
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<td>Jens Grebner(^1), Gernot Heilmann(^1), Marcel Dommasch(^1), Lukas M. Huber(^1), Eduard Studt(^1), Reiner Umuth(^1), Frank D. Sönnichsen(^1), and Rainer Herges(^1)</td>
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<td>(^1)Otto Diels Institute for Organic Chemistry, Kiel University, Kiel, Germany, (^2)Molecular Imaging North Competence Center, University Medical Center Schleswig-Holstein, Kiel, Germany, (^3)Institute of Physical and Theoretical Chemistry, Graz University of Technology, Graz, Austria, (^4)Medical Physics in Radiology, German Cancer Research Center, Heidelberg, Germany</td>
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The development of new photoswitchable contrast agents requires analysis with both NMR and MRI. In this work a combined probe head for \textit{in situ} light exposure is presented which can be used on NMR and MRI systems with both 7 Tesla. A probe head with four slanted quartz rods was fabricated. A dual tuned (\(1\)H and \(7\)H) Helmholtz coil was integrated into the probe head. NMR and MRI experiments were performed on photoswitchable solutions (e.g. contrast agents). Results show that photoswitchable solutions can be successfully switched \textit{in situ} and simultaneously analyzed with NMR or imaged with MRI.

| Plasma 6 | Evaluation of cardiac magnetic resonance thermometry in patients |
Recent studies have proposed to monitor radiofrequency ablation on the heart using real-time MR-thermometry. Methods rely on ECG triggering which can fail in presence of arrhythmia. This study evaluates the precision of MR-thermometry on patients (N=15) even in presence of cardiac arrhythmia. Phase images were acquired using a single-shot multi-slice echo planar imaging and temperature maps were calculated and displayed on the fly. ECG was recorded simultaneously for further analysis of cardiac rhythm and post-processing of temperature images. Stability of temperature mapping without RF-heating was evaluated in each pixel and correlated to the prevalence of arrhythmia.

ACDF is a surgical procedure performed when herniated disks produce severe pain, or arm/hand weakness. Severe complications occur in ~9% of cases, mainly due to tissue resection adjoining the spinal canal. MRI imaging, performed at several procedure stages, can visualize the extent of resection, and the degree of nerve decompression. We performed ACDF surgery on the MRI table, using an MRI-compatible tool-set. Imaging at 3T was performed at four procedure phases. Imaging disclosed significant spine decompression immediately after disk resection, with smaller changes after osteophyte and posterior longitudinal ligament removal. MRI-monitored ACDF can revise procedure phases, leading to improved outcomes.

A novel compressed sensing reconstruction method based on L+S separation on complex difference image domain data is demonstrated to perform better than existing methods on major applications in RF heating monitoring and MR guided focused ultrasound intervention.
We propose a semi-automatic processing pipeline for the generation of realistic radiofrequency models of deep brain stimulation (DBS) patients. The whole process takes ~72 hours for model generation and field computation and models the exact DBS path, without intersections, the internal structure of the implant and the patient’s anatomical structures (e.g., brain, bones, muscles, lungs). We show that simplification of the DBS implant model results in high (up to 75%) differences in the estimation of energy absorption. The proposed framework allows for fast and precise modeling, which may be needed, pending experimental validation, to evaluate MRI RF-induced heating.

**Poster: 7T Neuroimaging**

**Electronic Power Pitch Poster**

**Plasma 13**
Interventional Magnetic Resonance Imaging Guided Carotid Embolectomy using a Novel MRI-Conditional Resonant Catheter: Demonstration of Preclinical Feasibility

Jeffrey K. Yang1, Andre Cote1, Caroline D. Jordan1, Aaron Losey1, David McCoy1, Andrew Chui2, Jay F. Yu1, Teri Moore1, Carol Stillison1, Fabio Settecase1, Matthew D. Alexander1, Andrew Nicholson1, Mariam Aboian1, Daniel L. Cooke1, Maythem Saeed1, Dave Barry2, Alastair J. Martin1, Mark W. Wilson1, and Steven W. Heits1

1Department of Radiology and Biomedical Imaging, UCSF, San Francisco, CA, United States, 2Penumbra Inc, Alameda, CA, United States

MR-guided endovascular interventions can provide real-time imaging biomarkers for procedures such as stroke embolectomy. The purpose of this study is to determine preclinical feasibility and efficacy of imaging wireless resonant circuits embedded in a MR compatible catheter system for in vivo MR-guided carotid embolectomy in porcine stroke models. The resonant catheter system performed effectively under real-time MRI with recanalization rates (TICI 2b/3) similar to reported clinical rates in stroke embolectomy. Qualitative physiologic measures of flow under MRI were comparable to those measured under X-ray, demonstrating feasibility of resonant catheter system for in vivo carotid occlusion and embolectomy under real-time MRI.

**Plasma 14**
Acousto-optic Based Active MRI Marker for Interventional MRI Devices

Yusuf Samet Yaras1, Sarp Satir1, Cagla Ozsoy1, Rajiv Ramasawmy2, Adrienne E Campbell-Washburn1, Anthony Faranesh3, Robert Lederman3, Ozgur Kocaturk2, and Levent Degertekin1

1G.W. Woodruff School of Mechanical Engineering, Georgia Institute of Technology, Atlanta, GA, United States, 2Institute of Biomedical Engineering, Bogazici University, Istanbul, Turkey, 3Division of Intramural Research, National Heart Lung and Blood Institute, National Institutes of Health, Bethesda, MD, United States

Conspicuous and safe MR markers are essential for tracking interventional MRI devices. The RF induced heating on long conductors used in current active MR markers presents a safety risk. In this work, a novel acousto-optic active MR marker with optical fiber connection is proposed to eliminate RF induced heating. The proposed marker consists of a miniature coil coupled to a piezoelectric transducer which in turn modulates the reflected light in the optical fiber. The linearity of the acousto-optic active marker with flip angle is characterized and initial in vitro imaging experiments are performed demonstrating marker visibility under MRI.

**Plasma 15**
MRI based RF safety characterization of implants using the implant response matrix: a simulation study.

Janot P. Tokaya2, Alexander J.E. Raaijmakers1,2, Peter R. Luijten2, and Cornelis A.T. van den Berg1

1Radiotherapy, UMC Utrecht, Utrecht, Netherlands, 2Radiology, UMC Utrecht, Utrecht, Netherlands, 3Biomedical Image Analysis, Eindhoven University of Technology, Netherlands

We introduce a general description of the RF response of an implant, defined as the implant response matrix (IRM). An analytical expression for the IRM is derived through basis functions that depend on a limited number of parameters. This analytical model is validated with a simulation study (Pearson correlation coefficients with simulations R: 0.9979-0.9996). This description allows a significant reduction in unknowns enabling MRI assessment by MRI measurements without hardware modifications to scanner or implant. The feasibility of MRI based IRM/TF measurement is shown in silico. With the simulated complex B fields the IRM is accurately reconstructed (R: 0.974).

**Poster: 7T Neuroimaging**

**Exhibition Hall**

**Monday 9:15 - 10:15**

**Plasma 16**
The effects of B1+ correction of MP2RAGE on estimating cortical thickness and T1 at 7T

Roy Haast1, Dimo Ivanov1, Elia Formisano1, and Kamil Uluudag2

1Department of Cognitive Neuroscience, Maastricht University, Maastricht, Netherlands

B1+ inhomogeneities can significantly affect the quantitative T1 values derived from MP2RAGE data and also automatic tissue classification, in particular in the inferior temporal and frontal lobes. Here, we investigated the effects of post-hoc correction at 7T on the T1 and apparent cortical thickness using a B1+ map for the residual transmit inhomogeneities in MP2RAGE data. We found that B1+ correction reduces these inhomogeneities leading to (1) a lower inter-subject variability, (2) enhanced localization of the GM-CSF border and (3) more accurate cortical thickness measurements.
The relationship between cortical myeloarchitecture and functional connectivity in the human brain

Olivier E. Mounin1, Benjamin A.E. Hunt1, Prejais K. Tewarie1, Nicolas Geades1, Peter G. Morris1, Matthew J. Brookes1, and Penny A. Gowland1

1Sir Peter Mansfield Imaging Centre, School of Physics and Astronomy, University of Nottingham, Nottingham, United Kingdom

The human brain relies upon the dynamic formation and dissolution of functional networks to support ongoing cognition. The goal of this study is to establish a relationship between functional and structural networks. Using ultra-high field MRI, structural network defined by grey matter myelination is measured via quantitative Magnetization Transfer. Magnetoencephalography (MEG) was used to elucidate functional networks representing the major electrophysiological pathways of communication in the brain. Our study sheds new light on the way in which cortical microstructure supports functional networks.

Towards in vivo spinal cord cyto- and myeloarchitectures deciphering using multi-modal MRI parcellation at 7T

Manuel Tasso1,2,3, Aurelien Massire1,2,3, Pierre Besson1,2, Arnaud Le Trotur1,2, Maxime Guye1,2, Jean-Philippe Ranjeva1,2, and Virginie Caillot1,2,3

1CIRMAB, Aix-Marseille Univ, CNRS, Marseille, France, 2Pôle d’imagerie médicale, Hôpital de la Timone, CEMEREM, AP-HM, Marseille, France, 3Lab-Spine international associate laboratory, Marseille/Montreal, France

Ultra-high-field MRI offers exciting perspectives for the in vivo structural characterization of central nervous system tissues. Based on high-resolution multi-parametric imaging at 7T, this preliminary work focuses on the generation of new spinal cord (SC) templates, hence proposing a high-resolution T2*-w MR average with exquisite anatomical details. Parcellation of the SC substructures into individual WM tracts and motoneurone clusters was also investigated using classification methods and multimodal data (T1/T2/T2*DTI). Preliminary promising results revealed some insights in the underlying SC cyto- and myelo-architecture. Future developments will extend to the whole cervical cord, holding tremendous promises for studying more specific pathophysiological impairments.

7T Quantitative Magnetization Transfer (qMT) of Cortical Gray Matter in Multiple Sclerosis Correlates with Cognitive Disability

Lydia McKeithan1,2, Bailey D. Lyttle1,3, Bailey A. Box1, Kristin P. O’Grady1,2, Richard D. Dorch1,2,3, Benjamin N. Conradi1, and Seth A. Smith1,2,3,4

1Department of Biomedical Engineering, Vanderbilt University, Nashville, TN, United States, 2Vanderbilt University Institute of Imaging Science, Vanderbilt University Medical Center, Nashville, TN, 3Department of Radiology and Radiological Sciences, Vanderbilt University Medical Center, Nashville, TN, 4Department of Ophthalmology, Vanderbilt University Medical Center, Nashville, TN

Cognitive impairment (CI) is a major manifestation of multiple sclerosis (MS) and is responsible for extensively hindering patient quality of life. Cortical gray matter damage is critical to CI, but is poorly characterized by conventional MRI. We employed advanced methods by evaluating SIR-qMT-derived indices for differences between MS patients and healthy volunteers at 7T and derived associations with neuropsychological measures of cognitive impairment. We found significant reduction in k in cGM of MS patients, unique association with EDSS score, and strong correlation with cognitive performance indicating that k may be a significant biomarker of GM damage in MS.

Changes in structural network connectivity in early-stage multiple sclerosis are associated with cortical demyelination

Atef Badji1,2, Gabriel Mangeat1,2, Russell Ouellette1,2, Constantina Andrade Treaba1,2,3,4, Tobias Granberg1,2,3,4, Eileen Herranz1,2,4, Celine Louapre1,2,4, Nikolay Silkov1,2, Jacob Sloane1,2,3, Pierre Belles1, Catelina Mainero1,2,4, and Julien Cohen-Adad1,2,3,4

1NeuroPoly Lab, Institute of Biomedical Engineering, Polytechnique Montréal, Montreal, QC, Canada, 2Functional Neuroimaging Unit, CRiUGM, Université de Montréal, Montréal, QC, Canada, 3Athinaoul A. Martins Center for Biomedical Imaging, MGH, Harvard Medical School, 4Department of Clinical Science, Intervention and Technology, Karolinska Institutet, 5Montreal Health Institute, 6Beth Israel Deaconess Medical Center

Cortical disruption and changes in brain connectomics in multiple sclerosis have been recently investigated; however, the relationship between both processes in early disease remains uncertain. We propose an integrative framework that combines diffusion-based graph theory with high-resolution quantitative T1 and T2* at 7 Tesla to investigate the topological alterations of both structural connectomics and cortical demyelination. We found that both cortical myelin loss and increase in brain connectivity were present in early MS, and that the two processes were spatially anti-correlated. This suggests that the increase in brain connectivity in early MS could represent an adaptive response against initial, mild cortical demyelination, though this would be lost with more severe cortical disease.

3D magnetic resonance spectroscopic imaging at 7 Tesla of patients with medically refractory focal epilepsy with non-lesional or inconclusive clinical MRIs: First Results

Rebecca Emily Feldman1, Madeline Cara Fields2, Bradley Neil Deilmann1, Lara Vanessa Marcuse3, and Priti Batchand1

1Translational and Molecular Imaging Institute, Icahn School of Medicine at Mount Sinai, New York, NY, United States, 2Department of Neurology, Mount Sinai Hospital, New York, NY, United States, 3Radiology, Icahn School of Medicine at Mount Sinai, New York, NY, United States, 4Department of Neurology, Mount Sinai Hospital

SASSI is a B20-insensitive, low-SAR 7T MRSI technique with reduced chemical shift localization errors. We used 3D SASSI to image the hippocampi of patients with medically refractory focal epilepsy who had non-lesional or inconclusive clinical MRIs. Using SASSI at 7T, we detected decreases in the hippocampal NAA/Cr ratios in suspected temporal lobe epilepsy patients, on the same side as the seizure onset zones and/or 7T structural findings.

The value of 7T in the clinical evaluation of epileptic patients with focal cortical dysplasia

Kaibao Sun1,2, Xueyuan Wang3, Zhongwei Chen1,2, Chang Liu1, Jianfei Cui1, Zhentao Zuo1, Rong Xue2, Yan Zhuo1, Lin Chen1,2, Shuil Liang3, Tao Yu1, and Bo Wang3
Focal cortical dysplasia (FCD) is defined as topical malformations of cortical development and often results in intractable epilepsy. However, many epileptic patients with FCD have not been diagnosed because of the lack of high-quality magnetic resonance imaging. 7T MRI, in comparison with 3T, is assessed in this study to allow better characterization of lesion details and detect previously unrevealed FCD abnormalities. The results of comparison were classified for an accurate and appropriate appraisal.

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Individualized Tractography-Based Parcellation of the Globus Pallidus Pars Interna using 7T MRI in patients with Parkinson’s Disease Prior to DBS Surgery
Rémi Patriat¹, Yuval Duchin¹, Christophe Lenglet¹, Joshua Aman², Scott Cooper², Jerrold Vitek³, and Noam Harel¹
¹CAMRR / Radiology, University of Minnesota, Minneapolis, MN, United States, ²Neurology, University of Minnesota, Minneapolis, MN, United States

The success of deep brain stimulation (DBS) surgeries for Parkinson’s disease relies on the accurate placement of an electrode within the motor portion of subcortical brain targets. We use 7T MR-tractography to visualize the functional territories of the Globus Pallidus pars Interna. We found that the motor territory is located immediately postero-medially to the associative and limbic territories, akin to the subthalamic nucleus organization. This pattern was reproducible across two DBS patients. These findings shed new light on the functional organization of DBS targets, showing potential for providing valuable information to clinicians for targeting decisions and ultimately enhancing patient’s outcomes.

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Assessment of cerebral vascular abnormalities in Huntington’s Disease at 7Tesla
Richard J Dury¹, Sarah L Mason¹, Francesca Cicchetti¹, Janelle Drouin-Ouellet², Roger A Barker², Penny A Gowland³, and Susan T Francis¹
¹Sir Peter Mansfield Imaging Centre, University of Nottingham, Nottingham, United Kingdom, ²John van Geest Centre for Brain Repair, University of Cambridge, Cambridge, United Kingdom, ³Département de Psychiatrie & Neurosciences, Université Laval, QC, Canada

Huntington’s Disease (HD) is associated with vascular abnormalities and breakdown in the blood-brain barrier (BBB). Here, we use high spatial resolution time-of-flight magnetic resonance angiography (TOF-MRA) and arterial spin labelling (ASL) to assess vascular abnormalities in HD patients. We develop a pipeline to estimate vessel radii and distribution from TOF-MRA data. A significant decrease in the fractional vessel volume and a higher frequency of narrow vessels (0.15-0.45 mm radius) was evident in HD patients compared to healthy volunteers across a number of cortical areas. No significant difference was found in cortical perfusion between the HD patients and healthy volunteers.

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7T TOF-MRA Shows Different Patterns of Perforating Artery in Patients with Intracranial Atherosclerosis Disease (ICAD) and Cerebral Autosomal-Dominant Arteriopathy with Subcortical Infarcts and Leukoencephalopathy (CADASIL)
Qingle Kong¹, Qi Yang¹, Zhaoyang Fan², Xiangchong Zhang³, Yun Yuan⁴, Xiaojing Fang⁴, Jing An⁵, Yan Zhuo⁶, and Zihao Zhang⁷
¹State Key Laboratory of Brain and Cognitive Science, Beijing MRI Center for Brain Research, Institute of Biophysics, Chinese Academy of Sciences, Beijing, People’s Republic of China, ²University of Chinese Academy of Sciences, Beijing, People’s Republic of China, ³Xuanwu Hospital Capital Medical University, Beijing, People’s Republic of China, ⁴Chinese PLA general hospital, Beijing, People’s Republic of China

7T high-resolution TOF-MRA has the ability to image perforating arteries of middle cerebral artery (MCA). The distribution patterns of orifices in CADASIL (cerebral autosomal-dominant arteriopathy with subcortical infarcts and leukoencephalopathy) and ICAD (intracranial atherosclerosis disease) patients are still unclear. In this study, for the first time, we investigated the orientation distribution of perforating artery orifices on MCA trunks using 7T TOF-MRA. Specific features are found in the distribution patterns of orifices in patients with CADASIL, ICAD and healthy volunteers. This technique is promising in the pathological studies of intracranial vascular diseases.

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Intracranial vessel wall imaging in suspected cerebral vasculitis: evaluation of diagnostic value and treatment effects using 3T and 7T MRI
Nikki Dieleman¹, Anja G. van der Kolk², Catharina J.M. Frijns³, Anita A. Harteveld¹, Jaco J.M. Zwanenburg¹, Hugo J. Kuijf³, Arjen Lindenholz¹, L.Jaap Kappelle¹, Peter R. Luijten¹, and Jeroen Hendrikse¹
¹Radiology, University Medical Center Utrecht, Utrecht, Netherlands, ²Neurology, University Medical Center Utrecht, Utrecht, Netherlands, ³Images Science Institute, University Medical Center Utrecht, Utrecht, Netherlands

Cerebral vasculitis is a rare, but devastating disease that can lead to severe disability or death. Diagnosis is rather challenging, but for treatment purposes, an accurate diagnosis is crucial since different, more aggressive therapy is needed compared with non-inflammatory diseases. In the current study, we investigated the diagnostic value of intracranial vessel wall MRI at 3T and 7T in patients who were suspected of cerebral vasculitis. Our results show that intracranial vessel wall imaging at 3T and 7T MRI should be considered a promising non-invasive diagnostic tool to identify wall enhancement in patients with a suspicion of cerebral vasculitis.

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Detection of intracranial vessel wall lesions using 7T MRI: patients with posterior circulation ischemia versus healthy controls
Anita A. Harteveld¹, Anja G. van der Kolk¹, H. Bart van der Worp², Nikki Dieleman¹, Peter R. Luijten¹, Jaco J.M. Zwanenburg¹, and Jeroen Hendrikse¹
¹Radiology, University Medical Center Utrecht, Utrecht, Netherlands, ²Neurology and Neurosurgery, University Medical Center Utrecht, Utrecht, Netherlands
In this study presence and distribution of vessel wall lesions within the intracranial arteries of patients with recent posterior circulation ischemia and matched asymptomatic volunteers were assessed, using intracranial vessel wall MRI at 7T. Overall, vessel wall lesion presence and distribution were comparable between both groups. On arterial segment level, patients showed significantly higher lesion burden in the posterior cerebral artery, suggesting an association between posterior circulation lesion burden and ischemic events. Furthermore, a large amount of lesions showed contrast-enhancement, while the percentage of enhancing lesions was highest in the posterior circulation of the patient group.

Plasma 28
Metabolic differences between asymptomatic C9orf72 carriers and non-carriers assessed by brain 7T MRSI.
Henk-Jan Westeneng¹, Carrie Wismans¹, Abram D. Nijeti², Renée Walthout³, Peter R. Luijten⁴, Jannie P. Wijnen², and Leonard H. van den Berg¹

¹Department of Neurology, Brain Center Rudolf Magnus, University Medical Center Utrecht, Utrecht, Netherlands, ²Department of Radiology, University Medical Center Utrecht, Utrecht, Netherlands

Amyotrophic lateral sclerosis (ALS) is an incurable and fatal neurodegenerative disease, which is caused by a C9orf72 repeat expansion in 9% of the cases. This mutation may cause changes of brain metabolism in patients but whether it affects brain metabolism in pre-symptomatic mutation carriers was not studied before. We used 7 Tesla magnetic resonance spectroscopic imaging (MRSI) to study brain metabolism in asymptomatic carriers of the C9orf72 repeat expansion and found lower concentrations of glutamate and N-acetylaspartate-N-acetylaspartylglutamate in the left putamen compared to non-carriers. This might indicate asymptomatic neuronal loss, a developmental defect or possibly a protective mechanism against ALS.

Plasma 29
GABA and glutamate in children with Tourette Syndrome: a 7T 1H-MRS study
Nicolaas AJ Puts²,3, Richard AE Edden²,3, Matthew Ryan², E Mark Mahone⁴, and Harvey S Singer⁵

¹Russell H. Morgan Department of Radiology and Radiological Science, The Johns Hopkins University, Baltimore, MD, United States, ²FM Kirby Research Center for Functional Brain Imaging, Kennedy Krieger Institute, Baltimore, MD, United States, ³Department of Neuropsychology, Kennedy Krieger Institute, Baltimore, MD, United States, ⁴Department of Psychiatry and Behavioral Sciences, The Johns Hopkins University, Baltimore, MD, United States, ⁵Department of Neurology, The Johns Hopkins University, Baltimore, MD, United States

Studies have suggested that altered inhibition and excitation contribute to the pathology of Tourette syndrome, especially in cortical-striato-thalamic-cortical (CSTC) pathways. GABA and glutamate were measured at 7T in large cohorts of healthy children and children with TS in regions of the CSTC network. GABA and glutamate were increased in the striatum. Glutamate was increased in the premotor region and correlated with reduced motor inhibition. These data support involvement of habitual behavioral pathways in TS. Historically the dopaminergic system has been considered to have a dominant role in TS; however, accumulating evidence strongly suggests involvement of GABA and glutamate neurotransmitter systems.

Plasma 30
Multi-Parametric MRI at 7 T Enables Differentiation of MS and Age-Related White Matter Lesions
Zahra Hosseini¹,2, David A. Rudlo², Jacob A. Matusinec², Marcelo kremenchutzky¹, Ravi Menon²,³, and Maria Drangova¹,²,³

¹Biomedical Engineering Graduate Program, University of Western Ontario, London, ON, Canada, ²Imaging Research Laboratories, Robarts Research Institute, London, ON, Canada, ³Montreal Neurological Institute and Hospital, McGill University, Montreal, QC, Canada, ⁴Medicine, Schulich School of Medicine & Dentistry, University of Western Ontario, London, ON, Canada, ⁵Department of Clinical Neurological Sciences, Schulich School of Medicine & Dentistry, University of Western Ontario, London, ON, Canada, ⁶Department of Medical Biophysics, University of Western Ontario, London, ON, Canada, ⁷Imaging Research Laboratories, Robarts Research Institute

MRI enables visualization of white matter lesions associated with demyelination in multiple sclerosis (MS). However, subtle white matter hyperintensities are also a sign of normal aging. This study used information collected from multiple 7T MRI contrasts at baseline and four-month follow-up time points to compare signal changes in lesions of five MS patients to those of age-related lesions (ARLs) in five healthy controls.
Scott Charles Beeman1, Gordon Smith2, Joel Richard Garbow3, and Joseph JH Ackerman1,3

Development of a Noninvasive Beta Cell Functional Assay Using a Novel Zinc-Sensitive MRI Contrast Agent in Non-Human Primates

Insulin resistance is a defining feature of type 2 diabetes – a disease associated with severe morbidities and mortality. Recent studies have suggested that adipose tissue hypoxia is a major common pathway to systemic insulin resistance. The goals of this work are to: (i) directly observe evidence of the hypoxia-driven insulin resistance hypothesis in human subjects via gold-standard invasive pO2 measures and (ii) establish an R2*-based pO2 metric for future non-invasive studies of adipose pO2 in metabolic disease. Herein, we report initial progress towards these goals.

Measuring temperature in brown adipose tissue using the proton chemical shift

Clemens Diwoky1, Renate Schreiber1, and Rudolf Zechner1

1Institute of Molecular Biosciences, University of Graz, Graz, Austria

Within this work an approach based on the temperature dependence of the proton resonance frequency (PRF) of water and methylene bound protons is followed to monitor in-vivo thermogenesis in the interscapular brown adipose tissue (iBAT) of mice. Measuring the change in chemical shift difference of water and fat rather than water alone, known problems of PRF-based temperature measurements such as magnetic field drift and the temperature dependence of magnetic susceptibility are circumvented. The study determines the temperature coefficient in ex-vivo iBAT tissue extracts and presents the application of the technique in measuring norepinephrine stimulated in-vivo iBAT thermogenesis.

Development of a Noninvasive Beta Cell Functional Assay Using a Novel Zinc-Sensitive MRI Contrast Agent in Non-Human Primates

Catherine D. G. Hines1, Veronica Clavijo-Jordan1, Liza T Ganterl1, Stacey Conarello1, Christian Freih1,2, Sarah Chirayil1, Rachel Ortega1, Shu-An Lin1, Michael Klimas1, A. Dean Sherry1,2,3, and Jeff Evelhoch1

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Pancreatic beta cells secrete insulin to maintain normal blood glucose levels, and the integrity and function of pancreatic beta cells have been found to be compromised in Type-1 and Type-2 diabetes. Therefore, non-invasive beta cell function measurements may provide valuable information for improving diabetes diagnostics and disease management. Currently available diabetes assays lack functional information and spatial identification of properly functioning beta cells. In this work, we introduce a new assay to assess the function and identify functional beta cells in vivo in the non-human primate pancreas non-invasively with MRI using a Gd-based zinc sensor as contrast agent.

Feasibility of Estimating Placental Oxygen Metabolism in Pregnant Women $$$in$$$ $$$vivo$$$: Initial Experience

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The development of methods to assess placental oxygen metabolism would allow to clinically evaluate its function. Here, we evaluated the feasibility of estimating oxygen extraction and blood flow in some abdominal and fetal draining veins. Ovarian veins appear to play an important role in draining blood from the uterus in the supine position, where flow increased from the 2nd to 3rd trimester (16.4±8.1 versus 34.3±4.1 mL/min/100g). Additionally, elevation of oxygen saturation (61.6±6.6% versus 68.3±5.0%) at the umbilical vein occurred from the 2nd to 3rd trimester, potentially reflecting increased fetal oxygen demand as pregnancy progresses.

Free-breathing R2* Characterization of the Placenta During Normal Early Gestation Using a Multiecho 3D Stack-Of-Radial Technique

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Abnormal placental vascular development leads to ischemic-hypoxia thereby causing fetal growth restriction, preterm labor, and spontaneous abortion. Multiecho Cartesian MRI can characterize placental hypoxia by quantifying R2*, but is susceptible to motion artifacts. We have developed a new free-breathing (FB) multiecho R2* quantification technique using 3D stack-of-radial imaging (Radial). In n=16 subjects as part of an IRB-approved study, we observed an R2* range of 5 – 30s T at 3 T using the new FB Radial technique in the placenta during early normal gestation. Our new technique and the measured normative range of R2* may improve management of pregnancies with placental ischemic-hypoxia.

Respiratory $$$SSSalpha$$$-mapping of cystic fibrosis at 1.5T

Orso Pusterla1,2, Grzegorz Bauman1,2, Sylvia Nyilas1, Philipp Madörin1,2, Bernd Jung1, Michael Ith1, Ennio Stranzinger4, Urs Frey1, Philipp Latzin5, and Oliver Bieri1,2
Respiratory $$\alpha$$-mapping is based on native 1H multi-volumetric ultra-fast balanced steady-state free precession (ufSSFP) breath-hold imaging of the lung and provides whole lung isotropic pulmonary ventilation-related information. In this work, respiratory $$\alpha$$-mapping is evaluated in pediatric patients with cystic fibrosis (CF) and compared to functional lung parameters from nitrogen multiple-breath washout (N\textsubscript{-MBW}). The percentage of respiratory $$\alpha$$-impairments measured with $$\alpha$$-mapping is strongly correlated with the lung clearance index (LCI), a parameter for global ventilation inhomogeneity.

Recent studies have suggested the presence of a short-T2* signal component in the liver. The origin and MR properties of this signal have not been determined but have been shown to confound the liver fat quantification when using short echo times. In this work, we developed a UTE chemical shift-encoded MRI technique and a multi-component reconstruction to characterize short-T2* liver signals. A short-T2* signal fraction of 11.6±2.4% with an R2\textsubscript{p} of 222±261s\textsuperscript{-1} was measured in seven healthy volunteers. This study demonstrated the presence of the short-T2* signal component in healthy livers and provided an initial estimate to guide future studies.

Using a recently developed joint intravoxel incoherent motion (IVIM)-diffusion tensor imaging (DTI) protocol for kidney evaluation, we present reproducibility analysis of its metrics in normal volunteers, as well as pilot assessments in several patients with renal masses prior to surgery. Reproducibility analysis indicates a subset of robust parameters, including structural and microcirculation markers in both cortex and medulla, for clinical application. Preliminary results in renal mass patients suggest multifactorial differences from controls, supporting the need for advanced diffusion characterization in assessing renal functional reserve.
Liver Fat Reduction Following Bariatric Weight Loss Surgery is Greater in the Right Lobe of the Liver
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As liver fat is heterogeneously distributed, longitudinal changes in liver fat may vary between liver segments. We used confounder-corrected chemical-shift-encoded MRI to examine longitudinal changes in proton density fat fraction (PDFF) of individual liver segments in obese adults following a weight-loss program comprising a very low calorie diet (VLCD) followed by bariatric weight loss surgery (WLS). We observed that changes in PDFF in the 5-month postoperative period vary across segments, with right-lobe segments having more rapid reduction in liver fat.

In Vivo Biochemical and Histological Validation of Proton Density Fat Fraction as a Quantitative Biomarker of Hepatic Steatosis
Hepatic MRI-PDFF is positively correlated with R2* across a range of fat spectral models

Anatomical and functional deficits of the placenta identified by MRI in a rat model of preeclampsia

Electronic Power Pitch Poster
Poster: Highlights of Multiparametric Acquisition & Reconstruction

Relaxation in Polar Coordinates: Analysis and Optimization of MR-Fingerprinting

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Quantification of Flow by Magnetic Resonance Fingerprinting

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The goal of this work is to investigate and demonstrate ‘flow MRF’, a technique that quantifies T1 and T2 within static tissue regions around a vessel (e.g., vessel wall) with high spatial resolution while simultaneously quantifying the 3D blood velocity vector within the vessel with high precision and high spatiotemporal resolution. The results show that simultaneous mapping of pulsatile flow and T1/T2 quantification of static tissue is feasible with MRF. The quantification of flow as an additional parameter will further increase the efficiency of MRF and may provide new diagnostic value in cardiovascular diseases.

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Applications of Low Rank Modeling to Fast 3D Magnetic Resonance Fingerprinting (MRF)

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The goal of this study is to accelerate the acquisition time of 3D magnetic resonance fingerprinting (MRF) using a low-rank model-based method kt-SVD-MRF. With a total factor of 144 acceleration rate, 3D T1, T2 and proton density (M0) maps can be acquired from a whole brain scan with a resolution of 1.17x1.17x3 mm3 in 2.7 minutes.

Plasma 19

Magnetic Resonance Fingerprint Compression with Multiple Channel Transmission

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Singular value decomposition (SVD) and view-sharing compression can decrease the size of the dictionary without compromising accuracy in magnetic resonance fingerprinting (MRF). While the latter accounts for the B++, of multiple transmit channels in the dictionary, the SVD compression scheme was designed for single-channel transmission. In this work we extended SVD-based fingerprint compression to the case of two or more independent RF sources and evaluated its performance in simulation. We showed that accurate parametric maps can be achieved using only six SVD components, both in fully-sampled and highly under-sampled MRF experiments. Future work will include optimization of k-space under-sampling.

Plasma 20

Intra-Voxel Spatial Resolution Using Magnetic Resonance Fingerprinting

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We demonstrate the use of Magnetic Resonance Fingerprinting to retrospectively increase spatial resolution in slice-encoding direction, making use of the non-uniform nature of the excitation slice profile. Assigning individual fingerprints to substances present at different spatial positions within the excited voxel, a multi-compartment analysis recovers the spatial distribution of the components.

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Dictionary approach to partial volume estimation with MR Fingerprinting: Validation and application to brain tumor segmentation

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MR Fingerprinting signal evolutions can be used to estimate partial volumes of tissues in addition to tissue relaxation times. Two approaches to tissue fraction estimation, a pseudoinverse calculation and dictionary-based or constrained solution, are quantitatively compared in the presence of four potential error sources. The constrained approach is found to more accurately estimate tissue fractions, and also to improve segmentation of pathology.

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Mitigation of Spiral Undersampling Artifacts in Magnetic Resonance Fingerprinting (MRF) by Adapted Interleave Reordering

Josef Pfueffler1, Argyrios Kechagias1, Craig H. Meyer1, Gregor Körzdörfer1, and Mathias Nittka1

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Fat Signal Fraction Determination Using MR Fingerprinting

Jason Ostenson and E. Brian Welch

Magnetic resonance fingerprinting employs multiple echo times to quantify fat signal fraction both in phantoms and in vivo on a human 3 Tesla scanner. Reasonable agreement is seen in fat signal fraction maps and intra-class correlation between standard and MRF methods.

Accelerated Magnetic Resonance Fingerprinting using Soft-weighted key-Hole (MRF-SOHO)

Gastao Cruz, Andrea S. Gaspar, Tom Brujinjen, René Botnar, and Claudia Prieto

Magnetic Resonance Fingerprinting estimates multi-parametric maps from a series of highly undersampled time-point images. However, MRF scan times are still long due to the large amount of time-point images (~1000) required to produce accurate multi-parametric maps. Here we propose to exploit redundant information in time-point images with similar contrast to accelerate the MRF scan by further undersampling each time-point image and/or significantly reducing the number of required images in the series. The proposed approach achieved an acceleration factor of 5.7× compared to conventional undersampled MRF while maintaining parametric map quality.

Magnetic Resonance Fingerprinting - Evaluation of Brain Gliomas in Comparison to a Conventional Advanced Tumor Protocol - Preliminary Study

Siegfried Traatling, Wolfgang Bogner, Bernhard Strasser, Peter Bär, Simone Kitzer, Pavol Szomolanyi, Matthias Nittka, Wolfgang Mark, Martin Zalaudek, Markus Schreiner, and Elisabeth Springer

Synopsis: MR Fingerprinting (MRF) was compared to an advanced brain tumor protocol in 10 patients with surgically proven gliomas. The T1 and T2 relaxation times provided by MRF in one scan showed a high correlation with conventionally measured T1 and T2 values. MRF obtained T1 and T2 values allowed a statistically significant differentiation between low and high grade gliomas. MRF with quantitative data and the possibility to generate synthetic contrast images may replace conventional MR sequences in the future.

Joint estimation of arterial input function and tracer kinetic parameters from under-sampled DCE-MRI

Yi Guo, Sajan Goud Lingala, R Marc Lebel, and Krishna S Nayak

Direct reconstruction of tracer kinetic (TK) parameter maps from under-sampled DCE-MRI has recently been demonstrated. However, this method assumes the arterial input function (AIF) is known or pre-determined. Any mismatches between the assumed AIF and the underlying patient-specific AIF can cause large inaccuracies in the final TK parameters. We propose a novel approach to extract patient-specific AIFs from under-sampled data, while jointly estimating the TK parameter maps. Reconstruction is performed by cycling through the AIF extraction, TK parameter estimation, and data consistency. We demonstrate this approach on brain tumor DCE data sets, where high fidelity AIFs are extracted up to an under-sampling rate of 100×.

Highly accelerated DCE imaging with integrated T1 mapping

R Marc Lebel, Yi Guo, Sajan Goud Lingala, Richard Frayne, and Krishna S Nayak

Dynamic contrast enhanced (DCE) MRI requires accurate and precise baseline T1 and M0 maps for pharmacokinetic modeling. Advances in dynamic acquisitions and reconstructions have enabled high resolution DCE imaging with full anatomical coverage. Rapidly obtaining high SNR T1/M0 maps with the same spatial resolution has become a limiting factor for advanced DCE methods. We present a single highly accelerated acquisition that first performs the T1/M0 mapping then dynamic imaging. A model-based reconstruction is used to estimate the T1/M0 maps. This method makes effective use of scan time and generates maps that are superior to separately acquired ones.
Parallel imaging relies on fully-sampled calibration data to estimate k-space kernels or sensitivities used to reconstruct subsampled acquisitions. Emerging techniques use low-rank modeling, or joint estimation of sensitivities and image content via nonlinear optimization, to reduce the dependency on calibration data. In a typical study, images at multiple echoes/contrasts are acquired using the same coil sensitivities. Here, we exploit this joint information to dramatically improve conditioning of calibrationless nonlinear inversion and employ joint sparsity to improve reconstruction. To achieve better performance, we also propose complementary k-space undersampling between images to form a composite image with reduced aliasing to initialize the optimization.

We present an image reconstruction technique to accelerate cardiac diffusion tensor imaging by jointly applying a low-rank and spatial sparsity constraint. We evaluated four acquisition schemes at different undersampling levels on 9 ex vivo diseased human heart, evaluating the reconstruction quality based on the resulting helix angle (HA) maps and helix angle transmurality (HAT) values. A Wilcoxon signed rank test was performed to statistically evaluate changes in HAT to determine the highest achievable acceleration factor for each acquisition scheme. Our framework shows promise in greatly reducing scan time while preserving the fiber architecture features of heart failure.

The limitations of contact-based hardware (e.g. electrocardiography, pulse oximetry) for cardiac activity measurement pose an obstacle in many ultra-high-field MRI examinations. In this work, we present a freely available hardware and software system for acquisition and processing of video signals from human skin that we developed with the aim to make this contact-free method available to other researchers.
Global signal regression alters the correlation between resting-state BOLD fluctuations and EEG vigilance measures

Alex T. L. Leong, Xunda Wang, Russell W. Chan, Leon C. Ho, Yongrong Qiu, Celia M. Dong, and Ed X. Wu

A Multiband Multi-Echo Simultaneous ASL/BOLD Acquisition for Resting State Functional Connectivity

Alex T. L. Leong, Xunda Wang, Russell W. Chan, Leon C. Ho, Yongrong Qiu, Celia M. Dong, and Ed X. Wu

One grand challenge in contemporary neuroscience is to achieve an integrated understanding of large-scale brain-wide networks. Resting-state functional MRI (rsfMRI) has helped reveal such brain-wide networks, yet, the neural bases underlying them remain unclear. Utilizing opticogenetic excitation and pharmacological inactivation to manipulate the neural activity of somatosensory thalamocortical neurons, the present study demonstrated that rsfMRI connectivity is enhanced and decreased respectively. Furthermore, our findings suggest that optogenetically-evoked propagating low frequency activity (~1Hz) within the thalamo-cortico-thalamic network facilitate the enhancement of rsfMRI connectivity. Our work offers an exciting avenue to dissect the underlying neural bases of brain-wide functional connectivity.

What is the neurophysiological bases of resting state functional connectivity?

Maryam Falahpour, Aican Naicì, Chi Wah Wong, and Thomas Liu

Global signal regression (GSR) is a commonly used preprocessing approach in the analysis of resting state fMRI data. Utilizing simultaneously acquired EEG/fMRI data in humans, we found that GSR alters the correlation between the resting-state BOLD fluctuations and EEG vigilance. We show that GSR reveals BOLD-EEG correlations that are otherwise obscured and use a time segmentation approach to argue that the observed effects are not simply an artifact of GSR.

Functional Neuroimaging in the Brain using Magnetic Resonance Elastography

Samuel Patz, Navid Nazari, Paul E. Barbone, Ben Fabry, Dan Fovargue, David Nordsletten, and Ralph Sinkus

Using electrical stimulation of the hind limb, Magnetic Resonance Elastography (MRE) was used to observe localized changes in the complex shear modulus G=G' + iG'' of the mouse brain cortex. “Stimulation” and “no stimulation” paradigms were alternated every 10s to avoid habituation. An average increase of ~14% in G' was observed whereas no significant change was seen for G''. The effect was observed in six of seven mice studied. The mechanism responsible for this effect is hypothesized to be due to calcium influx into the neuronal cells.

Fully Automated Learning based Method for resting state fMRI Connectomes Analysis

Adivi Sreekumari, Rakesh Madhavan, Rakesh Mullick, Teena Shetty, Pratik Mukherjee, Joseph Masdeu, Luca Marinelli, and Suresh Emmanuel Joel

A multiband multi-echo simultaneous ASL/BOLD sequence was developed and utilized to evaluate resting state connectivity. ASL sequences have inherently long TRs due to the tagging and delay components. To compensate for this, four echoes were collected allowing multi-echo independent component analysis (ME-ICA) to be employed to denoise the BOLD data. A seed-based analysis was used for the computation of functional connectivity. Temporal signal to noise ratio (tSNR) was significantly higher for the denoised data resulting in an increase in connectivity strength, cluster size, and number of clusters. The sequence also allowed perfusion-weighted connectivity to be computed.
The first two years of whole brain functional development can be separated into three distinct time periods. Resting functional connectivity has been utilized to characterize early brain functional development. Most of the studies to date have grouped subjects based on biological age, enabling assessment of brain functional maturation. However, this grouping approach assumes that subjects at the same age exhibit similar functional maturation, which may not be valid considering the paces of functional maturation could substantially vary among individuals. In this study, the normalized-Cut method was used to cluster connectivity matrices of 71 normally developing children, 0 to 2 years of age, into distinct age periods (functional age) reflecting stable brain functional connectivity. We found that brain functional development during the first two years of life consists of three distinct time periods 0 – 2, 3 – 6, and 7 - 26 months, respectively. In addition, 17 core brain regions were identified, which largely drove our clustering results. These regions could be of critical importance for early brain development.

MRI Connectivity Predictors of Post-Surgical Seizure Outcome in Temporal Lobe Epilepsy

Surgical resection of the mesial temporal lobe is a common treatment of drug-resistant temporal lobe epilepsy (TLE). The ability to more accurately predict post-surgical outcome in these patients is a significant clinical challenge. Towards this end, MRI functional and structural connectivity were used to identify a common pattern across a seizure propagation network in TLE patients with seizure free outcome. Then, in test patients with good and bad outcomes, similarity with the model pattern was significantly associated with seizure outcome. Therefore, this non-invasive method may predict seizure outcomes in TLE, which was not possible from the clinical assessments alone.

CEST MRI at ultra-high magnetic field

BOLD indirectly measures brain activity based on neurovascular coupling, a reporter which is naturally poor in both its spatial and temporal resolutions. Emerging methods involving spectroscopy (IMRS) and diffusion fMRI suggest that metabolic and structural modifications are taking place in the activated cells. In this paper, we introduce Chemical Exchange Saturation Transfer (CEST)-weighted fMRI as a new method to explore changes in rat brain activation at 17.2T. Monte Carlo simulations were performed to optimize the acquisition and processing methods. Experimentally, CEST-weighted fMRI activation maps showed negative contrast at +1.2ppm most likely originating from changes in the glucose metabolism.

EPI-signal fluctuations at the cardiac frequency: A tissue-specific quantification of inflow, displacement and potential oxygenation effects over the cardiac cycle.

The impact and transmission mechanisms of the cardiac arterial pressure wave into brain tissue are not fully understood. It is hypothesised that age-related arterial stiffening and increased CBF pulsatility leads to propagation of the arterial wave further down the vascular tree causing tissue damage. Here we quantify inflow and displacement/oxygenation induced fluctuations of the EPI-signal at the cardiac frequency. We relate the EPI-signal phase to the fluctuations of $S_0$ and $T_2^*$ over the cardiac cycle.
Population Receptive Field Mapping of Human Somatosensory Cortex at 7 T

To advance the investigation of function and structure in human somatosensory areas, detailed topographic maps that are reproducible across time are invaluable. In previous 7 Tesla fMRI studies using travelling wave (TW) and event-related (ER) paradigms, the functional parcellation of digit representations in human S1 has been shown. Here, we present the application of ‘population Receptive Field’ analysis (pRF) to high-resolution fMRI data from somatosensory cortex. The pRF method can provide information beyond preferred stimulus location, such as measures of receptive field size. We also show how surface coils can be used to improve spatial resolution in somatotopic maps.

Resting state fMRI shows increased global synchrony in schizophrenia at rest, but mechanisms remain speculative. We tested mice with knockout of SynCAM1 (related to synaptic organization), LRRTM1 (related to schizophrenia symptoms) and both genes using whisker-stimulation and resting-state fMRI. SynCAM1 was linked to stronger whisker barrel activation and to greater functional connectivity. However, this was lost if global signal regression was performed. Global signal amplitude was significantly higher in SynCAM1 knockout mice, and amplified by the additional knockout of LRRTM1. We hypothesize this is due to disrupted synaptic connections by SynCAM1 knockout, which are partially protected when LRRTM1 is present.

Electronic Power Pitch Poster

Poster: Quantitation, Prediction & Machine Learning in the Brain

Exhibition Hall

Machine Learning Based Diagnosis of Early Parkinson's Disease using QSM

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This study proposed a support vector machine model to classify early PD patients from healthy controls using QSM. The results validated better performance of SVM than conventional logistic regression based on statistical ordering of backward feature selection. This computer aided technique may help to reduce misdiagnosis rate of early-PD patients.

Reproducibility of advanced MR metrics in a multi-site, multi-vendor study of mild traumatic brain injury

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The Advanced Research Core of the Concussion Assessment Research and Education consortium includes a multi-site, multi-vendor, multi-contrast imaging acquisition protocol with T2 FLAIR, quantitative T2⁰, task free fMRI, ASL, and DTI. This abstract describes the variance of measurements made in the first year and a half of the study from these imaging methods across a cohort of non-contact sport control athletes. With the variance of these measurements in the colligate athlete population known, the sensitivities of the individual and combined contrasts to diagnose injury and recovery can be assessed.

Characteristic Changes of Volume and Shape of Subcortical Structures in Obsessive-Compulsive Disorder

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We analyze subcortical nucleus volume and shape alterations in a relatively large sample of drug-naive adult patients with Obsessive-Compulsive disorder by using an automatically segmentation and vertex-based shape analysis protocol. Our findings indicated that (i) Gender effects were found in OCD, male patients seems are affected in reward system whereas females might have more disrupted stratum-pallidum-thalamus pathway which might be related to chronic stress. (ii) Shape analysis may provide more anatomical change information from a different perspective. Future structural research should consider shape and volume alterations together when explore brain changes.
Partial volume (PV) is the effect of having a mixture of tissues present within a voxel. This effect occurs in tissue borders and affects small structures such as small multiple sclerosis (MS) lesions. Ignoring PV effects in volumetry may lead to significant estimation errors. Here, we propose a novel automated MS lesion segmentation technique that takes PV effects into account. The proposed method shows higher accuracy in terms of lesion volume estimation compared to a manually segmented ground truth as well as a significant improvement in detection of small lesions, also in comparison to two software packages for MS lesion segmentation.

This study combines clinical brain cancer imaging and pathological microscopy with machine learning to generate predictive maps of pathological features (i.e. new contrasts) based on segmented histological cellularity. Predictive cytological topography (PiCT) maps of cellularity were utilized to detect additional pathologically confirmed infiltrative glioblastoma cellularity beyond margins of contrast enhancement.

Genetic alterations found in WHO grade 2 and 3 gliomas include IDH1/2 and TERT promoter mutations and 1p19q co-deletion. In this research, the authors attempted to test the hypothesis that genetic alterations could contribute to the locations and texture of the tumor by analyzing 201 WHO grade 2 and 3 gliomas using radiogenomic analysis. The authors were able to confirm the hypothesis that genetic alterations do contribute to the locations and textures of the tumor. 15 radiomic features were identified and those features were able to identify 3 genetic subgroups of WHO grade 2 and 3 gliomas.
The present study demonstrates the feasibility of machine learning in radiogenomics to predict patient outcome. The Random Forest Survival model is able to predict patient survival based on apparent diffusion coefficients or gene expression data without any prior knowledge.
Deep-Neural-Network based image diagnosis: comparing various image preprocessing strategies to achieve higher accuracy and understanding

We conduct the first systematic evaluation of the performance of three widely used registration software toolkits (FLIRT from FSL, NiftyReg and ANTs employing Spinal Cord Toolbox) in an effort to outline a method for reliable co-registration between anatomical and quantitative (EPI-based) spinal cord MRI. We generate a diverse set of registration pipelines and rank them according to quality of co-registration metrics. We find that ANTs and NiftyReg outperform FLIRT, and we report heterogeneity of specifications for optimal co-registration among software toolkits.

Cerebellum Tissue Segmentation with Ensemble Sparse Learning

Accurate segmentation of cerebellum is important in studying the structural changes in brain and the alert in different neuro-developmental disorders. However, cerebellum has received relatively little attention in the image processing literature, compared with cerebrum segmentation. In fact, cerebellum tissue segmentation is also very challenging due to severe partial volume effect and low contrast. In this study, an ensemble sparse learning is proposed for cerebellum tissue segmentation, where the goal is to segment the tissues in cerebellum into white matter (WM), gray matter (GM) and cerebrospinal fluid (CSF). The experiment results demonstrate that our proposed method show advantages in cerebellum tissue segmentation.

Poster: Best of Cardiovascular MR: Hemodynamics & Atherosclerosis

Utilizing Quantitative Measurements of Carotid Intraplaque Hemorrhage can Improve on Presence Alone in Classifying Patients with and without Acute Cerebral Infarcts

Histological studies have shown that intraplaque hemorrhage (IPH) size might be important in assessing disease severity. We hypothesize that the quantitative measurements of IPH by MRI provide additional value towards classify acute cerebral infarcts (ACI) in the carotid territory by brain MRI. We found that the subjects with ACI had larger max % IPH measurements (AUC=84.7%, p=0.015) and IPH closer to the lumen (AUC=85.4%, p=0.012). Further, using the size and distance measurements simultaneously improved the AUC to 96.9%. Beyond the presence of IPH, quantitative measurements of IPH may improve the predictive value of carotid plaque imaging for future stroke.

Whole-Brain Vessel Wall Imaging Using Inversion-Recovery Prepared SPACE: Reproducibility and Accuracy of Intracranial Artery Morphology

Intracranial atherosclerosis disease is one of the main causes for cerebrovascular events. A T1-weighted whole-brain vessel wall imaging method, inversion-recovery prepared SPACE (IR-SPACE), was developed at 3T demonstrating advantages over conventional SPACE. This study was aimed to determine the reproducibility of scan-rescan, intra-, and inter-observer as well as the accuracy when using the technique for morphology assessment of the intracranial vessel wall. In general, this study demonstrated excellent reproducibility and good agreement between the 3D and 2D techniques. In conclusion, IR-SPACE is a reproducible and accurate MR method for intracranial vessel wall imaging.
A Preliminary Report on Time-Resolved Coronary Vessel Wall MRI in Heart Transplant Recipients
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In this study, we applied a recently developed and robust coronary vessel wall MRI method that includes a golden angle trajectory and k-1 sparse SENSE to a cohort of heart transplant recipients. The coronary vessel wall was visualized with high contrast in all patients and the method holds great promise for quantitative and non-invasive characterization of coronary allograft vasculopathy (CAV) in transplanted patients.

Non-Gadolinium-Contrast Relaxation-Enhanced MR Angiography in Children with an Inversion Recovery and T2-Prepared 3D mDIXON Gradient-Echo Technique: Preliminary Experience
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We demonstrate the preliminary clinical feasibility and utility of a 3D non-Gadolinium MR angiography sequence called REACT (Relaxation-Enhanced MR Angiography without Contrast and Triggering) in 21 pediatric patients (age range: 1.7 – 16.1 years). REACT, which collectively utilizes T2-preparation, inversion recovery, and water-fat separation to suppress unwanted signals and exploit the long T1 and T2 times of unenhanced blood, is particularly beneficial in children, a population where Gadolinium administration should be minimized given recent concerns with residual intracranial Gadolinium deposition. We illustrate and compare REACT to Gadolinium-based MRA in the neck, upper and lower extremities, and the chest, abdomen, and pelvis.

Ultra-High Spatiotemporal Resolution 4D Flow for Valve and Coronary Arterial Delineation
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4D flow provides single sequence rapid protocol for assessment of blood flow, ventricular function, and anatomy in congenital heart disease. Though valve function has been well validated for regurgitant flow fraction, assessment of valve leaflet delineation has been limited by relatively low spatiotemporal resolution. Similarly, coronary origin delineation has been limited. Here, we develop an ultra-high spatiotemporal resolution 4D flow acquisition technique and assess its performance for valve and coronary delineation. 4D flow provides superior delineation of coronaries than echo, is highly likely to depict coronary origins, and is highly likely to provide good valve leaflet delineation.

Zixin Deng1,2, Sang-Eun Lee1, Zhanyang Fan1, Christopher Nguyen1, Ybin Xie1, Jianing Pang1, Xiaoming Bi1, Qi Yang1, Byoung-Wook Cho1, Jung-Sun Kim2, Daniel Berman1, Hyuk-Jae Chang1, and Debiao Li1
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In patients with suspected coronary artery disease undergoing invasive coronary angiography, approximately half has nonsignificant stenosis (stenotic lesions that may not induce ischemia), leading to frequent and unnecessary invasive procedures. Previously, we proposed a noninvasive technique for functional evaluation of coronary stenosis using PC-MRI and raver-stokes equations. In this study, we evaluated the feasibility of the technique in patients, using invasive fractional flow reserve as a reference. Good correlation was observed between noninvasive and invasive techniques with high specificity and negative-predictive-value, demonstrating the potential of the proposed technique in identifying patients with functionally nonsignificant stenosis and eliminating unnecessary invasive procedures.

Analysis of 4D flow hemodynamics parameters in BAV patients using a finite element method
Julio Solero1,2, Lydia Dux-Santoyo1, Andrea Guada1, Jose Rodriguez-Palomares1, Arturo Evangelista1, Daniel Hurtador, and Sergio Uribe4
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Bicuspid aortic valve (BAV) is one of the most common cardiac defects. The progression of the defect can vary with the time and may lead to ventricular dysfunction, heart failure and death of the patient. In this work we proposed a method to obtain several hemodynamics parameters including WSS, OSI, vorticity, helicity density, viscous dissipation, energy loss and kinetic energy from 4D-flow data sets of BAV patients and healthy volunteers using a finite-element approach. We found that the viscous dissipation, helicity density, vorticity, WSS and energy loss are the most relevant hemodynamics parameters in the ascending aorta of those patients.
Association between Carotid Atherosclerotic Plaque Calcification and Intraplaque Hemorrhage: A High Resolution Magnetic Resonance Imaging Study
Da Wang1,2, Jiaxin Shao1, Daniel B. Ennis1,2,3, and Peng Hu1,2

In this study, we propose a new and more efficient flow encoding and velocity calculation strategy for PC-MRI using a temporal modulation technique to double the temporal resolution or reduce the scan time by 50%. This is the first study to examine a temporal modulation strategy for an under-sampled M1-space (gradient first moment space including FC, FEx, FEy and FEz encoding steps). Our strategy can be combined with conventional acceleration techniques, i.e. parallel imaging and compressed sensing, to further shorten the scan time of PC-MRI.

Association between Age of Intraplaque Hemorrhage and Fibrous Cap Rupture in Carotid Artery Atherosclerosis: A High Resolution Magnetic Resonance Imaging Study
Jos Westenberg1, Pankaj Garg1, Pieter van den Boogaard1, and Sven Plein1

Carotid intraplaque hemorrhage (IPH) is associated with cardiovascular events. Calcification, frequently accompanied with IPH, may play a role in occurrence of IPH. In this study we aimed to investigate the associations between calcification characteristics and IPH in carotid plaques. Our results suggest that surface calcification and multiple calcifications in carotid atherosclerotic plaques are independently associated with presence of IPH. Both quantity and location of calcification may play important roles in occurrence of IPH. These findings may provide novel insights for understanding the mechanism of IPH.

Compressed Sensing based Simultaneous Black- and Gray-blood Carotid Vessel Wall MR Imaging
Xiao Li1,2, Hao Li1, Guofu Huang1, Xia Qian1, Wei Wang1, and Li Dong1

We sought to achieve high-quality simultaneous black- and gray-blood MR imaging using the CS based dual contrast imaging technique proposed on 2015. The performances on the blood suppression efficiency, image quality and morphological measurements for the CS based dual-contrast imaging technique were investigated. Seven healthy volunteers and five patients with carotid artery stenosis were recruited in this study. STR, CTR were calculated. LA and WA were measured. The comparisons for the black- and gray-blood image quality and the presence of plaque calcifications were implemented. This technique provides spatially matched black- and gray- images and excellent visualization for vessel wall imaging.

Comparison of acceleration algorithms in whole-heart 4D flow MRI for aortic and mitral valve flow assessment
Jos Westenberg1, Pankaj Garg1, Pieter van den Boogaard1, and Sven Plein2

Accelerated acquisition is required to make 4D flow MRI clinically feasible. In this study, three commonly used acceleration approaches are compared. Validation of flow volume and velocity assessment is performed in phantoms and comparison against conventional 2D phase-contrast is done across the aortic and mitral valve in 25 healthy volunteers. 4D flow MRI with echo-planar-imaging shows largest in vitro error in velocity assessment, however, the bias is within clinically acceptable margins. In volunteers, 4D flow MRI with echo-planar-imaging produces most reliable quantitative results in flow volume and velocity and presents the shortest acquisition time with satisfactory image quality.

Golden Step, Golden Angle, Spiral-Cartesian Imaging for Flexible Gated Three-dimensional Angiography
Grzegorz Tomasz Kowalik1, Jennifer Anne Steenden1, David Atkinson2, Kristian Mortensen3, and Vivek Muthurangu1,3

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As discussed, there is compelling evidence to support the notion that atherosclerotic calcification may play a role in occurrence of IPH. Both quantity and location of calcification may play important roles in occurrence of IPH. In this study we aimed to investigate the associations between calcification characteristics and IPH in carotid plaques. Our results suggest that surface calcification and multiple calcifications in carotid atherosclerotic plaques are independently associated with presence of IPH. Both quantity and location of calcification may play important roles in occurrence of IPH. These findings may provide novel insights for understanding the mechanism of IPH.
The purpose of this study was to develop and validate a novel 3D hybrid spiral-Cartesian MR angiographic sequence that utilized a golden step, golden angle acquisition strategy to enable flexible reconstruction.

We demonstrate that it is possible to acquire GSA-MRA and reconstruct it in a flexible manner (Real-time and cardial and/or respiratory gated reconstructions). This may enable better interrogation of anatomy.

The new flexible 3D MRA provide novel ways of assessing cardiac disease.

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**Plasma 14**

**Distribution of Intraluminal Thrombus Composition in Abdominal Aortic Aneurysms by Diameter: a High Resolution MRI study**

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Intraluminal thrombus (ILT) composition as identified by MRI has been suggested to be a marker of likely abdominal aortic aneurysm (AAA) progression. However, little is known about the distribution of ILT composition across different sizes of AAAs. This study investigated the ILT composition by AAA diameter in 62 patients from two centers. We found ILT distributed differentially by size, with an increasing mix of fresh and old ILT in larger AAAs. ILT composition is a potential indicator of AAA progression. Larger, prospective studies are needed to clarify its prognostic value in managing AAA patients.

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**Plasma 15**

**Evaluation of Portal Vein System in patients after liver transplantation by Unenhanced MR Angiography Using Spatial Labeling with Multiple Inversion Pulses Sequence and by CT portography**

hao tang1, daoyu hu, xiaoyan meng, zi wang, zhen li, and yanchun wang

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Unenhanced MR angiography with spatial labeling with multiple inversion pulses (SLEEK) is a reliable method for depicting portal vein system in patients with liver transplantation compared with computed tomographic portography (CTP) results. In a study of 20 patients who underwent liver transplantation, we found that there was excellent correlation between SLEEK and CTP in presenting the diameter of portal vein. Unenhanced MRA using SLEEK is relatively inexpensive and is not associated with renal complications. It can be as a good choice for screening portal vein system in patients with liver transplantation, especially in patients with renal insufficiency.

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**Plasma 16**

**Long-term Cerebrovascular Dysfunction Following Repeated Mild Traumatic Brain Injury**

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Pseudo-Continuous Arterial Spin Labelling (pCASL) was used to assess cerebrovascular dysfunction of mice having traumatic brain injury (TBI) - which had been induced via serial cortical impacts. Resting perfusion was quantified in absolute units via multiple post-label-delay pCASL experiments, and found to be reduced in the lesion. Furthermore, vascular reactivity to hypercapnic challenge, assessed via pCASL, appears to be enhanced in initial results. These results, in conjunction with immunohistochemical analysis and T2-weighted structural images, imply severe damage due to TBI, with vascular adaptation in the form of angiogenesis as the response from the brain.

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**Plasma 17**

**Comparative Study of 3D Arterial Spin Labeling and dynamic contrast-enhanced MRI of Nasopharyngeal Carcinoma perfusion imaging**

Bohan Xiao1, Zhaoxiang Ye2, Peiguo Wang4, Ying Lu1, Yingyu Zhao1, and Dandan Zheng2

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DCE-MRI is already a standard approach to evaluating tumor perfusion in NPC, but it may induce severe side-effects. ASL is a noninvasive MRI technique that has been mainly used to achieve perfusion imaging in central nerve system. In this study, we attempt to evaluate the application of ASL in NPC. Thirty-eight newly diagnosed NPC patients underwent 3D ASL and DCE-MRI perfusion scans on a 3.0-T MRI system. ASL BF value and DCE-MRI parameters were calculated and compared. Statistically significant correlation was found between them. Therefore, 3D ASL may provide a potential alternative to DCE-MRI in NPC diagnosis and therapy evaluation.

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**Plasma 18**

**Non-contrast vascular compliance mapping using time-resolved VASO CBV imaging**

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Vascular compliance reflects the stiffness of arterial vessel wall and has been related to a number of diseases, such as cardiovascular disease, cerebral arteriosclerosis, and hypertension. However, the vascular compliance at intracranial arteries has been rarely measured due to limited availability of effective methods. In this work, a 3D VASO-CBV-based MR technique was developed to assess the arterial CBV change with respect to pulsation and thus estimate vascular compliance. With this technique, we were able to map vascular compliance along the intracranial arterial tree.

Spatial distributions of the propagation patterns of cerebrospinal fluid (CSF) motion driven by cardiac pulsation and respiration were visualized using velocity waveform correlations based on asynchronous 2-dimensional phase contrast imaging. These two different driving mechanisms were evaluated using spectral analysis of the velocity waveforms for 11 healthy subjects. Delay time maps and maximum correlation maps showed the spatial distribution differences between the cardiac-driven and respiratory-driven CSF motion propagations. Maximum correlation at the prepoint was 0.83±0.05 for cardiac propagation and 0.74±0.04 for respiratory propagation with a significant difference (p << 0.01). Strong propagation may not necessarily cause large CSF displacement.

During infant brain development, rapid neuronal growth requires increases of cerebral blood flow. In this study, we quantified cerebral blood flow (CBF) at regional level during infant development by using pseudo-continuous arterial spin labeled (pCASL) perfusion MRI. The CBF maps at different infant stages from 0 to 24 months were revealed. The trend lines of CBF at specific regions were charted. It has been found that the CBF increases linearly at different brain regions, with CBF increasing faster in visual, posterior cingulate, medial prefrontal and inferior parietal cortex than whole brain.

Within-subject differences of T1, T2, and cortical thickness can be used to automatically parcellate the cortex, e.g. to guide functional analyses or increase statistical power. Here, we evaluate the additional benefit of baseline CBF as a marker for brain metabolism to differentiate regions. We demonstrate that CBF data is not redundant with the other quantitative MRI parameters. Therefore, a data-driven parcellation of brain regions that incorporates perfusion information allows delineation of the cortex into smaller units and enhances subsequent anatomical & functional analysis.

Mild traumatic brain injury (mTBI) or concussion disturbs both cerebral blood flow (CBF) and functional connectivity in intrinsic connectivity networks (ICNs). Using pulsed arterial spin labeling (PASL), we derived both CBF and ICNs in mTBI patients and investigated brain CBF responses to network disruptions. We observed that mTBI patients have decreased connectivity within the default mode network (DMN) in two regions as well as increased CBF in a third region which overlaps the DMN. The mismatch of these regions suggests potential repair or compensation for injury.
The length scales associated with parenchymal oxygen extraction fraction (OEF), coupled with the near uniformity of normative OEF across the brain dictate the development of an imaging approach that is sensitive to low-spatial frequency imaging behavior. Previous approaches to measure OEF using MRI have utilized high-pass-filters—effectively removing much of the signal. We propose a new method to filter out geometric field inhomogeneity, by imaging temporally through the cardiac cycle. In a study in 11 patients with intracranial atherosclerotic disease, we found elevated OEF on the compromised hemisphere as compared to the healthy contralateral side (p<0.0195).

We verified that venous blood T1 quantified in vivo in humans using fast and non-invasive MRI can be used to derive hematocrit (Hct) values reliably. This Hct information can be used for a more individual estimation of oxygen extraction fraction (OEF) from venous blood T2 measurements. Furthermore, inverse correlation between Hct and baseline cerebral blood flow (CBF) was observed across subjects. Measurement of Hct, OEF and CBF allowed determination of oxygen delivery (OD=CBF∙Hct) and consumption (cerebral metabolic rate of oxygen, CMRO₂=CBF-Hct∙OEF). When compared to CBF, OD and CMRO₂ showed less inter-subject variations among normal volunteers.

We proposed a novel multi-band multi-echo pseudo-continuous arterial spin labeling (M2-PCASL) method to simultaneously measure the cerebral blood flow (CBF) and the blood oxygen level dependent (BOLD) signal. Increased spatial resolution was achieved compared to the conventional method, and experiments were also conducted to show simultaneous measurement of CBF and BOLD signal dynamics in response to hypercapnia. M2-PCASL can be a useful tool for measuring cerebrovascular reactivity and studying neurovascular coupling in various conditions.

In this study, we propose to obtain simultaneous measurements of blood oxygen saturation (SO₂) and hematocrit (Hct) by combining two or more in vivo measurements of blood MR relaxation times. We tested our approach in 5 healthy human subjects using T2+T1 values and calibration curves obtained in vitro. The results found in the superior sagittal sinus vein (SO₂=62±5% and Hct=46±1%) are in good agreement with literature values and suggest great potential of the approach once it is further validated.

Velocity-selective (VS) MRA, a non-subtractive technique and allows large spatial coverage and slow-flow depiction has shown recent promise for cerebral applications at 3T. Here, we improved the velocity-selective saturation (VSS) pulse train by reducing its sensitivity of tissue suppression to $B_0$ inhomogeneity for both the intracranial and cervical regions. Moreover, we propose that arteriograms or venograms can be obtained by placing spatially selective inversion pulses before the acquisition to selectively null signals from venous or arterial blood. The feasibility of these technical advances for VS MRA is demonstrated on healthy volunteers at 3T.
A Method for Quantitative Cerebrovascular Reserve

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In the occurrence of damage to the hemodynamic system of the brain, a response is elicited by changes in the supply of blood and oxygen to the tissue. Depending on these different changes, the severity of the hemodynamic impairment can be defined. In this study, we propose a method of accurately measuring quantitative cerebrovascular reserve. This is achieved by applying water correction factors to multiple contrast-agent injection cerebral blood flow measurements. In multiple studies involving volunteers, animal model, and patients, we confirm the correction factors and compare against microsphere perfusion.

Robust Visualization of MCA Main Trunk by Improved Acceleration-Selective Arterial Spin Labeling (iAccASL) for Intracranial MR Angiography

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Improved acceleration-selective arterial spin labelling (iAccASL) was implemented for intracranial MR angiography and images were acquired in six healthy volunteers. Additional 180° refocusing pulses in control module will efficiently suppress spin dispersion and flow voids in strongly accelerating middle cerebral artery (MCA) main arteries. The vessel visualizations of MCA main trunk and peripheral vessels were compared with our previously reported AccASL and conventional time-of-flight (TOF) approach. We demonstrated iAccASL could produce better MCA main trunk visualization (without venous signal) compared with conventional AccASL technique with better peripheral visualization than TOF.

Proton Density Fat Fraction Estimation Accuracy of High-Flip-Angle, Contrast-Enhanced, Magnitude-Based Multi-Gradient-Echo MR Imaging at 3T

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Proton density fat fraction (PDFF) is a widely-used magnetic resonance imaging (MRI)-based biomarker for noninvasive quantification of hepatic steatosis. PDFF derived from low-flip-angle magnitude-based multi-gradient-echo MRI (MRI-M) without intravenous contrast has been shown to have high accuracy for estimating fat fraction. However, this MRI-M technique has a relatively low signal-to-noise ratio (SNR), which makes it difficult to visualize anatomical features. In this analysis of ninety-two patients, high-flip-angle contrast-enhanced (with either gadobutrol or gadobenate dimeglumine) MRI-M imaging had no significant difference in fat-grading accuracy from the standard low-flip-angle pre-contrast PDFF, using MR spectroscopy (MRS)-PDFF as the reference standard.

Assessment of liver function using an uptake ratio based on multiple-time points hepatocyte mapping

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We calculated the uptake fraction (k15) based on a pharmacokinetics model of gadolinium ethoxybenzyl-diethylenetriamine pentaacetic acid (Gd-EOB-DTPA) uptake using R1 changes in the hepatocyte. The k15 and ΔT1 values were compared to indexes determined by 99mTc-GSA scintigraphy for three different scan time points. The correlation coefficients of the blood clearance indexes (HH15) and receptor indexes (LHL15) were 0.307 and 0.497 for the ΔT1 and 0.537 and 0.570 for k15 values, respectively. The results indicate that the proposed quantification value of k15 is a more robust index for liver function compared with the ΔT1 value.
Detection of Advanced Liver Fibrosis and Cirrhosis using MR elastography compared to liver surface nodularity measurement, EOB-DTPA uptake and blood tests

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This study compares the diagnostic performance of multiparametric MRI including qualitative and quantitative assessment of MR-elastography (MRE), liver surface nodularity (LSN) software measurement, hepatic enhancement ratios on Gd-EOB-DTPA (EOB-ER), and serum markers (APRI and FIB4) for the detection of liver fibrosis and cirrhosis. When comparing different MRI methods and serum markers with histologic findings, liver stiffness measured with MRE showed better performance than other methods for detection of advanced liver fibrosis and cirrhosis, especially when combined with blood tests (FIB4).

Diagnostic performance of LI-RADS major features, ancillary features, and categories on MRI for diagnosis of hepatocellular carcinoma

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The study aimed to evaluate the diagnostic performance of LI-RADS major features, ancillary features, and categories for the diagnosis of HCC. Our results suggest that interpretation that includes ancillary features increases the sensitivity, while preserving a high specificity for definite HCC and a slightly lower specificity for probable HCC. Further, ancillary features in favor of benign entities have high specificity for benignity.

Longitudinal Characterization of Liver Regeneration and Portal Hemodynamics in Living Donor Liver Transplant

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The purpose of this study was to evaluate longitudinal liver regeneration and hemodynamic changes of living donor liver transplant (LDLT) donors in response to surgical liver resection. Five living related liver donors were studied. Subjects were imaged using 4D Flow MRI before and at several times following partial hepatectomy. The ability to longitudinally evaluate liver regeneration and portal hemodynamic changes non-invasively demonstrates that 4D flow MRI is a suitable tool for both surgical planning of LDLT, and for improved understanding of the liver regeneration and hemodynamic changes that occur in the remnant liver of the donor.

4D flow MRI of Liver Hemodynamics: Influence of Velocity Encoding, Different Field Strength and Contrast Application on Visualization and Quantification of blood flow

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4D flow MRI offers the possibility for complete volumetric and functional assessment of liver blood flow in patients with liver cirrhosis. This study reveals a significant difference when using a lower venc for visualization of the portal vein branches. Similar results are obtained for contrast application and different field strengths. For qualitative assessment of the intrahepatic branches by 4D flow MRI a lower venc is recommended.

Quantitative Free-Breathing Dynamic Contrast-enhanced MRI in Hepatocellular Carcinoma Using Gd-EOB-DTPA: Correlations With Ki67 Proliferation Status and Histological Grades

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This study aims to validate a free-breathing DCE-MRI in HCC patients using gadoxetic acid, and to determine the relationship between DCE-MRI parameters and histological results. Perfusion parameters (Ktrans, Kep, Vp, and iAUC) from 34 patients were compared with CT results and correlated with Ki67 indices and the histological grades of HCC. Significant relationship was found between DCE-MRI and CT results, indicating the validity of this protocol in evaluating the vascular change of HCC. The DCE-MRI derived Ktrans and IAUC were significantly correlated with the histological grades of HCC, suggesting the potential of those parameters in predicting the malignancy of tumors.

The value of high resolution gadoxetic acid-enhanced MR cholangiography for evaluating biliary anatomy of living liver donor: comparison with T2 weighted (T2W) MR cholangiography and conventional gadoxetic acid enhanced MR cholangiography
Water-Only Look-Locker Inversion recovery (WOLLI) T mapping

Epidemiology and spatial heterogeneity of hepatic fat and iron deposition: an MRI-based analysis

Region-of-interest size of hepatic 2D MR elastography decreases with increasing R2* for gradient-echo but not spin-echo techniques

Prognostic Role of Liver Stiffness Measurement Using Magnetic Resonance Elastography in Patients with Compensated Chronic Liver Disease

Liver stiffness measurement (LSM) using magnetic resonance elastography (MRE) can estimate the degree of liver fibrosis. We retrospectively evaluate the prognostic role of LSM using MRE in compensated chronic liver disease patients. A total of 217 patients with compensated chronic liver disease who underwent MRE were included. After a mean and median follow-up of 44.5±17.8 months and 46.0 months, LSM value obtained from MRE was turned out to be significant predictive factor for overall survival, development of hepatic decompensation and occurrence of hepatocellular carcinoma.

MRI has emerged as a reliable, noninvasive means of liver fat and iron quantification. We retrospectively studied 1006 patients that underwent standard-of-care liver MRI at a single tertiary care center. Multivariate analysis was used to identify factors predictive of the severity and spatial heterogeneity of hepatic fat deposition (HFD) and hepatic iron deposition (HID). Greater spatial heterogeneity of HFD and HID generally occurred as the severity of HFD and HID increased, suggesting higher risk for misclassification by biopsy with more advanced disease. Overall, by globally evaluating the liver, MRI constitutes a robust tool for assessing hepatic fat and iron deposition.
Free breathing T2* mapping of the Liver using a compressed sensing reconstruction
Paul de Heer, Oliver J Gurney-Champion, Jurgen H. Runge, Remy Klaassen, Jasper Schoormans, Bram F. Coolen, Hanneke W.M. van Laarhoven, Gustav J. Strijkers, Jaap Stoker, and Aart J. Nederveen

Hemochromatosis (iron overload) occurs in a range of liver disease. Iron content can be measured invasively with liver biopsy but is commonly replaced by non-invasive MR measurements, including T2* mapping. This is commonly done in a breath-hold to reduce the effects of respiratory motion. In this work we show that a stack of stars radial golden angle T2* mapping multi echo sequence during free breathing in combination with CS reconstruction facilitates high resolution imaging in the liver. This approach bears promise beyond liver imaging for visualizing smaller organs and pathologies, e.g. the pancreas and lymph nodes.

Wave-CAIPI for Highly Accelerated MP-RAGE Imaging
Daniel Poik1,2, Kawin Setsompop1,3, Stephen F. Cauley1,2, Borjan A. Gagoski1,2, Himanshu Bhat1, Florian Maier1, Lawrence L. Wald1,3, and Berkin Bilgic1,3

We introduce a highly accelerated T1-weighted MP-RAGE acquisition that utilizes a novel reordering scheme and Wave-CAIPI encoding to retain high image quality. R=9-fold accelerated in vivo MP-RAGE scans were performed in 71 sec, with maximum and average g-factor of g=1.27 and g=1.06. Compared to the state-of-the-art 2D-CAIPIRINHA method, this is a factor of 4.6/1.4 improvement in g /g. In addition, we demonstrate a 57 sec acquisition at 7T with R=12-fold acceleration. This acquisition had a g-factor performance of g =1.15 and g= 1.04. Wave encoding overcomes the g-factor noise amplification penalty and allows for an order of magnitude acceleration of MP-RAGE acquisitions.

Differential Domain Analysis for 3D Cartesian Sampling
Evan Levine and Brian Hargreaves

Selection of arbitrary 3D Cartesian sampling patterns for support-constrained MRI, parallel MRI, and dynamic MRI can be heuristic, and g-factor calculations require a computationally expensive simulation. To provide theoretical guidance and a method to optimize 3D Cartesian sampling, a novel concept of a differential distribution is introduced to represent a distribution of pairwise differences between sample locations, and is related to point-spread-functions. Its relationship to noise amplification in a generalized sensitivity encoding model and linear reconstruction is then used to efficiently optimize multidimensional k-space sampling. Examples in support-constrained MRI, parallel MRI, and dynamic MRI demonstrate reduced noise amplification.

Comparison of 2D and 3D MR Liver Elastography in 600 Patients
Bogdan Dzyubak, Kevin J. Glaser, Sudhakar K. Venkatesh, and Richard L. Ehman

2D Magnetic Resonance Elastography (MRE) is a validated method for staging liver fibrosis via liver stiffness measurements produced by introducing and imaging acoustic waves. Newer 3D MRE additionally images waves propagating out-of-plane. This retrospective study compared 2D and 3D liver MRE stiffness measurements across 600 patient exams. The two methods had excellent agreement, with 3D MRE yielding 6% lower stiffness and having lower failure rate. 3D MRE, which has the same acquisition time, is a good alternative for liver imaging as it does not suffer from out-of-plane propagation bias and has the added potential to characterize smaller abdominal organs.
Plasma 20

Calibrationless Parallel Imaging Reconstruction Using Hankel Tensor Completion (HTC)
Yilong Liu1,2, Jun Cao1,2, Mengye Lyu1,2, and Ed X. Wu1,2

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Autocalibrating parallel imaging requires sufficient autocalibration signals (ACS) for reliable estimation of coil sensitivity. However, this is not feasible in some applications, for example, spectroscopic imaging where matrix size is relatively small. Recent publications (SAKE, P-LORAKS, and ALOHA, etc.) proposed to construct k-space data into block-wise Hankel matrix, and perform parallel imaging reconstruction with low rank matrix completion. In this study, we propose to construct a block-wise Hankel tensor, and use tensor completion techniques to synthesize the unacquired samples. This method can also be extended to reconstruct multiple slices simultaneously and provide more accurate reconstruction.

Plasma 21

Highly Accelerated Magnetic Resonance Elastography via Bayesian Modeling
Christopher Ebersole1,2, Rizwan Ahmad1, Adam Rich1, Lee C. Potter3, and Arunark Kolipaka2

1Electronic and Computer Engineering, The Ohio State University, Columbus, OH, United States, 2Radiology, The Ohio State University Wexner Medical Center, Columbus, OH, United States

While magnetic resonance elastography (MRE) provides a non-invasive method of estimating tissue stiffness, which is indicative of a variety of diseases, MRE scans typically require lengthy breath-holds which are prohibitive for many patients. We have extended a recently proposed Bayesian imaging method, called ReVEAL, for MRE. This method is capable of reconstructing images from highly undersampled data by leveraging both sparsity and the near equal magnitude across multiple offsets, inherent to MRE acquisition, as reconstruction constraints. This reconstruction method is validated against SENSE using a retrospectively downsampled phantom dataset and three retrospectively downsampled in vivo liver datasets.

Plasma 22

RACE-GRASP: Respiratory-weighted and Aortic Contrast Enhancement-guided GRASP MRI
Li Feng1, Krishna Shanbhogue1, Daniel K Sokidinson1, Hersh Chandarana1, and Ricardo Otazo3

1Center for Advanced Imaging Innovation and Research (CAI2R), New York University School of Medicine, New York, NY, United States

This work proposes a technique named RACE-GRASP (Respiratory-weighted and Aortic Contrast Enhancement guided Golden-angle RA dial Sparse Parallel imaging) for robust free-breathing DCE-MRI of the liver. First, the aortic contrast enhancement curve is automatically detected from continuously acquired data and is used to guide k-space sorting to ensure precise capture of desired contrast-enhancement phases. Second, k-space data of each contrast phase are binned into different respiratory motion states, and each motion bin is weighted differently during image reconstruction to reduce motion blurring. The performance of RACE-GRASP was demonstrated in 5 healthy volunteers and was compared with conventional GRASP.

Plasma 23

Real-time 3D cardiac MRI using through-time radial GRAPPA and GPU-enabled reconstruction pipelines in the Gadgetron framework
Dominique Franson1, James Ahad1, Jesse Hamilton1, Wei-Ching Lo1, Yun Jiang1, Yong Chen1, and Nicole Seiberlich1,2

1Biomedical Engineering, Case Western Reserve University, Cleveland, OH, United States, 2School of Medicine, Case Western Reserve University, Cleveland, OH

An accelerated 3D cardiac dataset (8 partitions; in-plane spatial resolution: 2.34 x 2.34 mm; partition thickness = 8 mm) can be reconstructed using through-time radial GRAPPA and GPU-enabled pipelines in the Gadgetron framework in approximately 515.5 ms. This work may enable real-time, 3D imaging in the heart with on-line reconstruction.

Plasma 24

Navigator-free EPI ghost correction using low-rank matrix modeling: Theoretical insights and practical improvements
Rodrigo A. Lobos1, Tae Hyung Kim1, W. Scott Hoge2,3, and Justin P. Hatton1

1Electrical Engineering, University of Southern California, Los Angeles, CA, United States, 2Radiology, Brigham and Women’s Hospital, Boston, MA, United States, 3Radiology, Harvard Medical School, Boston, MA, United States

While the formation of ghost-free images from EPI data can be a difficult problem, recent low-rank matrix modeling methods have demonstrated promising results. In this abstract, we provide new theoretical insight into these approaches, and show that the low-rank ghost correction optimization problem has infinitely many solutions without using additional constraints. However, we also show that SENSE-like or GRAPPA-like constraints can be successfully used to make the problem well-posed, even for single-channel data. Additionally, we show that substantial performance gains can be achieved over previous low-rank ghost correction implementations by using nonconvex low-rank regularization instead of previous convex approaches.

Plasma 25

Non-ECG First-Pass Myocardial Perfusion T1 Mapping with Low-Rank Tensor Cardiovascular MR Multitasking
Anthony G. Christodoulou1, Jaime L. Shaw1, Xiaoming Bi2, Behzad Shariat1,2, and Debiao Li1,2

1Biomedical Imaging Research Institute, Cedars-Sinai Medical Center, Los Angeles, CA, United States, 2Cedars-Sinai Heart Institute, Cedars-Sinai Medical Center, Los Angeles, CA, United States, 3Department of Bioengineering, University of California, Los Angeles, Los Angeles, CA, United States, 4Siemens Healthcare, Los Angeles, CA, United States, 5Department of Biomedical Sciences, Cedars-Sinai Medical Center, Los Angeles, CA, United States
Quantitative first-pass myocardial perfusion imaging is a potentially powerful tool for diagnosing coronary artery disease. However, quantification is complicated by ECG misfires and the nonlinear response of signal intensity to contrast agent concentration. Here we propose a method overcoming the curse of dimensionality to simultaneously image cardiac motion, contrast dynamics, and T1 relaxation in 2D and 3D, using a low-rank tensor imaging framework for cardiovascular MR multitasking. This non-ECG, first-pass myocardial perfusion T1 mapping method accounts for the signal intensity nonlinearity, allowing direct quantification of contrast agent concentration at any cardiac phase in any cardiac cycle.

T1-T2 Shuffling: Multi-Contrast 3D Fast Spin-Echo with T1 and T2 Sensitivity
Jonathan I Tamir1, Valentina Taviani2, Shreyas S Vasanawala2, and Michael Lustig1
1Electrical Engineering and Computer Sciences, University of California, Berkeley, Berkeley, CA, United States, 2MR Applications and Workflow, GE Healthcare, Menlo Park, CA, United States

Volumetric fast spin-echo (3DFSE) imaging is clinically desirable because of its robustness to off-resonance and its utility for obtaining many types of image contrasts at isotropic resolution. However, its routine clinical use is inhibited by blurring due to long echo trains needed to maintain scan efficiency. Here we present T1-T2 Shuffling, a 3DFSE-based acquisition and reconstruction scheme that mitigates image blur and retrospectively synthesizes T1-weighted and T2-weighted image contrasts. The acquisition, an extension of T2 Shuffling, employs a randomizing echo train view ordering with variable repetition times (TRs). The use of short TRs increases scan efficiency while providing T1 sensitivity.

Simultaneous T1/T2 Measurements in Combination with PCA-SENSE Reconstruction (T1* Shuffling) and Multicomponent Analysis
Julian Pflister1, Martin Blaimer1, Peter M. Jakob1, and Felix A. Breuer1
1Magnetic Resonance and X-ray Imaging, Fraunhofer Development Center X-ray Technology (EZRT), Würzburg, Germany, 2Experimental Physics 5, University of Würzburg, Würzburg, Germany

An inversion recovery TrueFISP sequence with a golden angle based radial readout in combination with a view sharing KWIC filter reconstruction is able to produce quantitative M0, T1 and T2 maps within a single shot. However the KWIC filter leads to temporal blurring especially at high spatial frequencies. Here, we propose an alternative reconstruction method based on the principal component analysis (PCA) for providing an improved temporal fidelity. Furthermore this approach is extended for a multicomponent analysis by an inverse Laplace transform. Results from brain measurements demonstrate that this technique can identify different tissue types within a single voxel.

Accelerated 3D Multispectral MRI with Robust Principal Component Analysis for Separation of On and Off-resonance Signals
Evan Levine2, Kathryn Stevens2, and Brian Hargreaves2
1Electrical Engineering, Stanford University, Stanford, CA, United States, 2Radiology, Stanford University, Stanford, CA, United States

3D multispectral imaging (MSI) corrects most distortion in MRI near metallic implants at the cost of prolonged scan time by phase encoding to resolve slice distortions. However, existing methods to accelerate 3D MSI do not exploit the redundancy of slice-phase encoding for the dominant on-resonance signal. A novel compact representation of 3D-MSI images based on a decomposition of on- and off-resonance via robust principal component analysis (RPCA) is introduced to exploit this redundancy in a calibration and model-free reconstruction and push the current limits of accelerated 3D MSI. A complementary randomized sampling strategy is used to vary undersampling in different spectral bins to enable the separation. Experiments with retrospective and prospective undersampling show comparable image quality between standard MSI images and 2.6-3.4-fold accelerated RPCA and improvement over bin-by-bin compressed sensing reconstruction.

Field Map Combination Method for Multiple-Acquisition bSSFP
Anjali Datta1 and Dwight G Nishimura1
1Electrical Engineering, Stanford University, Stanford, CA, United States

FIESTA-C/CISS enables the reconstruction of banding-free bSSFP images, but residual ripple remains in the combined images. Also, in the heart, flow near a stop-band may cause a component image to include significant contributions from out-of-slice spins; this hyper-intense signal persists in images combined using conventional methods. Here, we use a B0 map to combine FIESTA-C/CISS cardiac cine images. Knowledge of B0 enables us to only include pass-band signal in the final image and exclude stop- and bright-bands. In phantom and in vivo studies, the proposed method had less ripple and greatly reduced flow artifacts compared to maximum-intensity projection and root-sum-of-squares.

Stochastic Primal-Dual Optimization for Locally Low-Rank MRI Reconstruction: A Stable Alternative to Cycle Spinning
Joshua D. Trzasko1
1Radiology, Mayo Clinic, Rochester, MN, United States

Locally low rank (LLR) reconstruction is an effective strategy that has found application across a range of MRI applications. In lieu of processing all overlapping image blocks each iteration, most LLR implementations employ “cycle spinning”, where only a random subset of blocks is processed. Cycle spinning improves efficiency, but may compromise reconstruction convergence and introduce artifacts. We propose a primal-dual algorithm for LLR reconstruction and show that stochastically updating the dual variable provides similar computational advantage as cycle spinning but avoids its primary disadvantages. Reconstruction performance benefits are demonstrated on both a numerical phantom and in vivo.
<table>
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<th>Plasma 1</th>
<th>Three-dimensional holographic visualization of high-resolution myocardial scar on HoloLens</th>
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<td>Jihye Jang1, Gifty Addae1, Warren Manning1, and Reza Nezafat1</td>
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<td>1Department of Medicine, Beth Israel Deaconess Medical Center and Harvard Medical School, Boston, MA, United States, 2Department of Computer Science, Technical University of Munich, Munich, Germany, 3Department of Radiology, Beth Israel Deaconess Medical Center and Harvard Medical School, Boston, MA, United States</td>
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We present a framework for 3D holographic visualization of high-resolution 3D late gadolinium enhancement (LGE) of myocardial scar on augmented-reality glass HoloLens via two approaches; 1) voxel-wise 3D scar rendering and 2) surface projection of the scar. Holographic visualization of high-resolution 3D LGE data will provide a true 3D perception of the complex scar architecture with an immersive experience to explore the clinical standard LGE images in a more interactive and interpretable way, which may facilitate MR-guided scar-related ventricular tachycardia ablation.

| Plasma 2 | Inducibility of ventricular arrhythmia correlates with the indices of myocardial viability using manganese enhanced MRI (MEMRI) in a porcine ischemia reperfusion model |
| Atsushi Tachibana1,2, Junaid Zaman1, Yuko Tada1, Michelle R. Santoso1, and Philip C. Yang1 |
| 1Cardiovascular Medicine, Stanford University, Stanford, CA, United States, 2Radiology, AIC Yaesu Clinic, Tokyo, Japan, 3Graduate School of Human Health Sciences, Tokyo Metropolitan University, Tokyo, Japan |

Peri-infarct region (PIR), containing the viable but injured myocardium, has been related to the occurrence of ventricular arrhythmia. Reliable in vivo detection of arrhythmogenic region presents significant challenge. While delayed enhanced MRI (DEMRI) with gadolinium (Gd) detects the myocardial infarction, the non-specific property does not detect the viable but injured cardiomyocytes in the PIR. Manganese (Mn) enters the live cells via L-type calcium channel, and enables dual enhancement technique to identify the overlapping viable region in PIR. We measured the correlation between the volume of the PIR and inducibility of ventricular arrhythmia using porcine ischemia reperfusion model.

| Plasma 3 | In Vivo Hyperpolarized MRS Study Showing Improved Cardiac Metabolism in Type 1 Diabetes with Daily L-Carnitine Treatment. |
| Dragan Savic1, Kerstin N. Timm. Vicky Ball, Lisa Heather, and Damian J. Tyler |
| 1University of Oxford, Oxford, United Kingdom |

Carnitine acts as a buffer of acetyl-CoA units in the mitochondria, as well as facilitating transport of fatty acids, and carnitine levels are decreased in the diabetic heart. The purpose of this study was to investigate the effect of L-Carnitine supplementation on cardiac function and metabolism in the diabetic rat heart. We show that daily injections of L-Carnitine can alter cardiac metabolism in the in vivo diabetic rat heart, and can increase flux through pyruvate dehydrogenase. Such studies will allow a better understanding of the interactions between metabolism and function in the diabetic heart and may provide new insight into novel therapeutics.

| Plasma 4 | Integrated T2 preparation and Inversion Recovery pulse (T2IR) for combined myocardium T1 and T2 mapping |
| Rui Guo1, Zhenwen Chen1, Jianwen Luo1, and Haiyan Ding1 |
| 1Center for Biomedical Imaging Research, Department of Biomedical Engineering, School of Medicine, Tsinghua University, Beijing, People’s Republic of China |

In this study we designed a novel hybrid T1 and T2 magnetization preparation pulse (T2IR) and implement a combined T1 and T2 mapping sequence based on MOLLI scheme. Phantom experiments showed that the proposed sequence has high consistency with reference methods for both T1 (R=0.99) and T2 (R=0.97) measurements. In vivo results showed that high quality T1 and T2 maps of myocardium could be obtained by the proposed sequence.

| Plasma 5 | Non-contrast assessment of vasodilator response using native myocardial T1 and T2 mapping and Arterial Spin Labeled CMR |
| Nilesh R Ghugre1,2,3, Hung P Do4, Kenneth Chu5, Venkat Ramanan5, Krishna S Nayak5, and Graham A Wright1,2,3 |
| 1Physical Sciences Platform, Sunnybrook Research Institute, Toronto, ON, Canada, 2Schulich Heart Program, Sunnybrook Research Institute, Toronto, ON, Canada, 3Department of Medical Biophysics, University of Toronto, Toronto, ON, Canada, 4Department of Physics and Astronomy, University of Southern California, Los Angeles, CA, United States, 5Ming Hsieh Department of Electrical Engineering, University of Southern California, Los Angeles, CA, United States |

Myocardial vasodilator response is an important indicator of microvascular function and integrity in ischemic injury. The objective of our study was to systematically compare myocardial stress response with native contrast mechanisms involving quantitative T2, T1 and Arterial spin labeled (ASL) imaging. Our findings suggest that oxygenation (T2 BOLD effect), blood volume (T1 effect) and perfusion (ASL) taken together could offer a complementary contrast-free framework to identify vasodilator dysfunction in heart disease. These could potentially offer insights into the myocardial remodeling process particularly in the remote territory, which develops hypertrophy and fibrosis in the high-risk patients in the chronic stage.

| Plasma 6 | Dictionary-based Reconstruction for Free-Breathing Myocardial T1 Mapping |
| Jinkyu Kang1, Jihye Jang1, Vahid Tarokh2, and Reza Nezafat1 |
| 1University of Oxford, Oxford, United Kingdom, 2University of Southern California, Los Angeles, CA, United States |
In this study, we propose a novel reconstruction framework for myocardial $T_1$ mapping based on a dictionary-based reconstruction algorithm that simultaneously reduces scan time while compensating for respiratory and cardiac-induced motions between different $T_1$-weighted images of $T_1$ mapping sequence.

**Validation of Cardiac Diffusion Tensor MRI using Transparent Tissue Preparation (CLARITY) with 3D Optical Microscopy**

Christopher Nguyen, Sang-Eun Lee, Jongjin Yoon, Huyk-Jae Chang, Sekeun Kim, Chul Hoon Kim, and Debiao Li

1Biomedical Imaging Research Institute, Cedars-Sinai Medical Center, Los Angeles, CA, United States, 2Division of Cardiology, Yonsei University College of Medicine, Seoul, Korea, Republic of, 3Department of Pharmacology, Yonsei University College of Medicine, Seoul, Korea, Republic of, 4Bioengineering, University of California Los Angeles, Los Angeles, CA, United States

The myocardium consists of a complex 3-dimensional (3D) microstructure has been shown to be perturbed in the presence of myocardial ischemia. Recently, diffusion tensor magnetic resonance imaging (DT-MRI) was introduced which can characterize the 3D tissue microstructure in intact myocardium. However, past histologic validation of DTI has been limited since traditional pathology allows only 2D optical microscopy after potentially destructive tissue sectioning. We present a novel approach to validate the derivation of the myocardial fiber orientation (MFO) using DT-MRI with 3D histology using a non-destructive, transparent-tissue preparation technique (CLARITY). Results indicate MFO derived from 3D histology and DT-MRI are strongly concordant.

**Free-breathing Black-blood Prepared Cardiac Diffusion Tensor Imaging**


1Institute for Biomedical Engineering, ETH and University Zürich, Zürich, Switzerland

In vivo cardiac Diffusion Tensor Imaging (DTI) can be influenced by myocardial perfusion. To address this limitation, reference images with moderate diffusion weighting can be employed, which, however, reduce diffusion contrast and require the acquisition of three orthogonal diffusion encoding directions. In this work, blood suppression was implemented using black blood preparation to reduce contribution of perfusion to the diffusion weighted signal. This allows for the use of a marginally weighted reference image resulting in a reduction in scan time by about 17% with improved or comparable accuracy of diffusion metrics relative to previous methods.

**First-Pass Nitroxide-Enhanced MRI for Imaging Myocardial Perfusion without Gadolinium**

Sophia Xinyuan Cui and Frederick H. Epstein

1Biomedical Engineering, University of Virginia, Charlottesville, VA, United States, 2Radiology, University of Virginia, Charlottesville, VA, United States

First-pass MRI using gadolinium-based contrast agents is widely used to image myocardial perfusion. However, gadolinium is contraindicated for patients with severely impaired renal function (a substantial portion of heart disease patients), and methods that do not employ gadolinium are needed. Nitroxide stable free radicals are non-metallic compounds with an unpaired electron and, correspondingly, are paramagnetic and $T_1$-shortening. We investigated first-pass nitroxide-enhanced perfusion MRI of the heart as an alternative to first-pass gadolinium-enhanced MRI. Five C57Bl/6j mice underwent first-pass imaging with the nitroxide agent 3CP and the results showed that nitroxide-enhanced MRI can quantify regional myocardial blood flow, as the average myocardial perfusion was 7.0±1.3 ml/g/min, a value in the normal range for mice.

**Cardiac fMRI - A Novel Approach for Reliably Detecting Myocardial Oxygenation Changes with Precise Modulation of Arterial CO2**

Hsin-Jung Yang, Ilkay Oksuz, Michael Klein, Olivia Sobczyk, Damini Dey, Jane Sykes, John Butler, Xiaoming Bi, Behzad Sharifi, Ivan Cotic, Debiao Li, Piotr Slomka, Frank S Prato, Joseph Fisher, Sokritos Tsafarlis, and Rohan Dharmakumar

1Cedars Sinai Medical Center, Los Angeles, CA, United States, 2IMT School for Advanced Studies Lucca, 3University of Toronto, 4Lawson Health Research Institute, 5Siemens Healthcare

Although cardiac BOLD MRI can detect ischemic heart disease without ionizing radiation and contrast agents, its reliability remains poor due to the low sensitivity and specificity. We propose a novel strategy to overcome these barriers through: (i) an improved MRI strategy with free gas-exchange capability; (ii) repeat stimulation of heart using a validated prospective arterial CO2 targeting technique; and (iii) a statistical framework to increase the confidence measure of BOLD signal changes. Our results show that the proposed approach can be used to significantly increase the confidence in detecting myocardial BOLD response in conditions of health and disease.

**High-fat diet feeding in mice may partially protect the heart from pressure overload induced heart failure - a longitudinal study of cardiac metabolism and function**

Emmy Manders, Desiree Abdurrachim, Miranda Nabben, Klaas Nicolay, and Jeanine J Prompers

1Department of Biomedical Engineering, Biomedical NMR, Eindhoven University of Technology, Eindhoven, Netherlands, 2Department of Genetics and Cell Biology, CARIM school for cardiovascular diseases, Maastricht University, Netherlands, 3Department of Radiology, University Medical Center, Utrecht, Netherlands
Obesity increases the risk of heart failure, but obese heart failure patients have a better prognosis and survival. Altered cardiac energy metabolism is proposed to be an important contributor to this discrepancy. With an in vivo longitudinal approach measuring cardiac function (MFR), energetics (P-MRS) and lipid content (H-MRS) during the development of heart failure we have shown that cardiac function was less impaired in obese mice compared with lean mice after induction of pressure overload. This suggests that metabolic adaptations in obese mice are not detrimental and may even be beneficial in heart failure development.

Cardiac Magnetic Resonance Elastography for Quantitative Assessment of Elevated Myocardial Stiffness in Cardiac Amyloidosis

Arvin Arani1, Shivalaram P. Arunachalam2, Ian CF Chang3, Francis Baffour4, Kevin J Glaser5, Joshua D Trzasko1, Kiran McGee1, Armando Manduca1, Martha Grogan1, Angela Dispensieri6, Richard L Ehman1, and Philip A Araoz1

1Radiology, Mayo Clinic, Rochester, MN, United States, 2Cardiovascular Diseases, Mayo Clinic, Rochester, MN, United States, 3Medicine: Division of Hematology, Mayo Clinic, Rochester, MN, United States, 4Laboratory Medicine and Pathology, Mayo Clinic

Myocardial stiffness plays an important role in cardiac function. The objective of this study is to evaluate if 3D high frequency cardiac MR elastography (MRE) can measure increased myocardial stiffness in cardiac amyloidosis patients compared to healthy volunteers. Twenty-two patients with cardiac amyloidosis and 16 healthy volunteers were enrolled. The myocardial stiffness of cardiac amyloid patients (median: 11.4 kPa, min: 9.2, max: 15.7) was found to be significantly stiffer (p < 0.01) than healthy controls (median: 8.2 kPa, min: 7.2, max: 11.8). These results motivate future investigation of 3D high frequency cardiac MRE in different patient cohorts.

Low Rank Compressed Sensing Reconstruction for More Precise Cardiac MRF Measurements

Jesse Ian Hamilton1, Yun Jiang1, Dan Ma1, Yong Chen2, Shivalari Pawha2, Wei-Ching Lo1, Joshua Batesole2, Mark Griswold1,2, and Nicole Geierich1

1Biomedical Engineering, Case Western Reserve University, Cleveland, OH, United States, 2Radiology, University Hospitals, Cleveland, OH, United States

A low rank compressed sensing and parallel imaging reconstruction termed Sparse MRF is introduced to improve the precision of mapping myocardial T2 and T2 with MR Fingerprinting. Sparse MRF enforces data consistency while also constraining the temporal signal evolutions using a low dimensional subspace derived from the SVD of the dictionary along time. Different reconstruction parameters are investigated in simulations with a cardiac phantom. Results from phantom and in vivo cardiac scans indicate that Sparse MRF yields approximately the same mean T2 and T2 measurements as other MRF matching techniques but with smaller standard deviations.

Electronic Power Pitch Poster

Poster: New Molecular & Metabolic Imaging Approaches

Exhibition Hall Tuesday 17:15 - 18:15

Dynamic Hyperpolarized 13C Metabolic Imaging of Patients with Brain Tumors
Hyperpolarized 13C MRS of the Human Heart

In vivo pH imaging using hyperpolarized 13C-labelled zymonic acid

In vivo metabolic imaging of neuroinflammation following traumatic brain injury using hyperpolarized [1-13C] pyruvate

Dynamic 13C data were acquired following injection of hyperpolarized [1-13C]pyruvate from 3 patients previously diagnosed with glioblastoma. Pyruvate, lactate and bicarbonate signal with high SNR were detected in human brain. Lactate/Pyruvate appeared to be relatively high in the contra-lateral, normal appearing brain. In contrast, tumor regions produced higher Lactate/Bicarbonate than contra-lateral brain. The contrast-enhancing lesion of one patient, who underwent surgical resection shortly after 13C imaging due to suspected recurrence, produced a relatively low level of Lactate/Pyruvate compared to contra-lateral brain and Lactate/Bicarbonate similar to the value in contra-lateral brain. Subsequent biopsy of the contrast-enhancing lesion indicated treatment effect.

Hyperpolarized 13C MRS of the Human Heart

In vivo metabolic imaging of neuroinflammation following traumatic brain injury using hyperpolarized [1-13C] pyruvate

This study demonstrates that metabolic imaging of hyperpolarized [1-13C] pyruvate can detect increased hyperpolarized lactate production in vivo in a preclinical model of Traumatic Brain Injury. Correlative assays further demonstrate that this increased lactate is linked to the presence of pro-inflammatory macrophages that upregulate pyruvate dehydrogenase kinase 1, subsequently leading to regional pyruvate dehydrogenase inhibition. Metabolic imaging of hyperpolarized [1-13C] pyruvate thus has great potential to provide a novel tool for in vivo detection of neuroinflammation.

Toward Dynamic 3D Cardiac Perfusion Imaging Using bSSFP and Hyperpolarized tert-Butanol

Perfusion imaging is a promising application for hyperpolarized tracers, as they provide high signal with no endogenous background. Hyperpolarized 13C labeled tert-butanol is a perfusion agent with long T1 and T2 relaxation times in vivo. Moreover, because it diffuses freely through tissue, bolus injections of tert-butanol are largely extracted from the vasculature on a first pass, and the residence time in tissue is on the order of tens of seconds. This provides a long time frame for dynamic imaging. Here we demonstrate the feasibility of time-resolved 3D cardiac perfusion imaging in rats.

Detection of Bacteria-specific metabolism using hyperpolarized 13C pyruvate

Bacterial infection is a major health problem, with high morbidity and mortality. Current imaging techniques have limited ability to differentiate infection from either tumor or sterile inflammation, and invasive tissue sampling is frequently required. There is currently no clinically-available non-invasive method to directly detect living bacteria in vivo. We describe a method for detecting bacteria specific metabolism using hyperpolarized 13C pyruvic acid.
A new method for measuring T$$_{1\rho}$$ of hyperpolarized radioactive isotopes using gamma rays

Yuan Zheng$^{1,2}$, Gordon D. Cates$^1$, William A. Tobias$^1$, and G. Wilson Miller$^{2,3}$

$^1$Department of Physics, University of Virginia, Charlottesville, VA, United States, $^2$IUI America, Houston, TX, United States, $^3$Radiology and Medical Imaging, University of Virginia, Charlottesville, VA, United States

We have developed a novel technique that combines MR and gamma detection for measuring T$\rho$ of radioactive isotopes. Gamma-ray emission is anisotropic with respect to the polarization direction of hyperpolarized radioactive nuclei (spin>1/2). When the spins are flipped into the transverse plane and subjected to a spin-locking field, the emission anisotropy also precesses and gamma detectors in the transverse plane will observe an oscillating count rate. Decay of the oscillation amplitude during SL can be used to fit T$\rho$. This technique also vastly reduces the number of spins needed for a meaningful measurement since gamma-ray detection is highly efficient.

Occupational Manganese Exposure: Reversibility of Increased GABA Levels and Brain Mn Accumulation

David A. Edmondson$^1$, Ruoyun Ma$^1$, Chien-Lin Yeh$^1$, S. Elizabeth Zauber$^2$, Sandy Snyder$^1$, Eric Ward$^2$, and Ulrike Dydak$^1$

$^1$School of Health Sciences, Purdue University, West Lafayette, IN, United States, $^2$Department of Neurology, Indiana University School of Medicine, Indianapolis, IN, United States

While manganese (Mn) is known in the pre-clinical community as a T1 contrast agent, it is also notorious as a neurotoxin that can cause irreversible parkinsonian symptoms at high enough exposure levels. In an occupational setting, workers are exposed to Mn through processes such as welding, smelting, and other metalwork. As the workload changes over time, so does the level of exposure. Using MRI and MRS, effects of exposure such as elevated thalamic GABA levels and brain Mn deposition can be detected and show evidence of reversibility. This may help identifying meaningful no-observed-adverse-effect levels (NOAEL) as used in occupational settings.

CM101: an optimized MR probe targeting type I collagen for detection of liver fibrosis

Christian T. Farris$^1$, Richard Kennan$^2$, Eric Gale$^1$, Ian Ramsay$^1,3$, Ricard Masia$^4$, Gunisha Arora$^5$, Kailyn Looby$^1$, Ian Weil$^6$, Michelle Bunzer$^2$, Chunlian Zhang$^1$, Yonghua Zhu$^1$, Taro Akiyama$^1$, Michael Klimas$^1$, Shirly Pinto$^1$, Himashinie Dijabalanage$^1$, Valerie Humblett$^1$, Bryan C. Fuchs$^1$, and Peter Caravan$^1$

$^1$Athinoula A. Martinos Center for Biomedical Imaging, Department of Radiology, Massachusetts General Hospital and Harvard Medical School, Charlestown, MA, United States, $^2$Merck Research Laboratories, Kenilworth, NJ, United States, $^3$Collagen Medical, Belmont, MA, United States, $^4$Pathology, Massachusetts General Hospital, Boston, MA, United States, $^5$Surgical Oncology, Massachusetts General Hospital, Boston, MA, United States

Recent molecular MR approaches targeting collagen demonstrated the promise of noninvasive detection and staging of liver fibrosis and monitoring treatment response, but the molecular probe used was not suitable for clinical translation due to the low stability of the Gd chelator chosen. CM-101 is a new peptide based probe using the highly stable Gd-DOTA chelate that is rapidly eliminated from plasma intact into the urine and shows no sign of Gd accumulation. CM-101 robustly detected liver fibrosis in a bile duct ligation model in rats and in a CCl$_4$ mouse model.

A high-throughput imaging pipeline is presented to quantify the heterogeneity in longitudinal disease progression in mouse models of human brain cancer and to test the efficacy of novel anti-cancer therapeutics in accurate mouse models of sporadic human cancer.

In vivo quantification of iONP-labeled PAR T-cells using positive contrast MRI

Jinjin Zhang$^1$, Sidatam C Kumarappuruma$^1$, Qi Shao$^1$, Lakmal Kotewawala$^2$, John C Bischof$^2$, Carston R Wagner$^2$, and Michael Garwood$^1$

$^1$Center for Magnetic Resonance Research, Department of Radiology, University of Minnesota, Minneapolis, MN, United States, $^2$Department of Mechanical Engineering, University of Minnesota, Minneapolis, MN, United States
Immunotherapies have received increasing attention as novel therapeutics for the treatment of cancer and autoimmune disease. In this study, IONP labeled PAR T-cells were tracked and quantified in vivo using the SWIFT sequence for positive contrast imaging and T1 mapping. The longitudinal relaxation rate constant (R1) showed a linear dependence on the cell density in vitro and thus was used to quantify T cell density in vivo in liver. These preliminary results demonstrate how positive contrast from an ultra-short T2 sensitive sequence can provide a tool to quantify the bio-distribution of T cells.

Synopsis: We demonstrate the capability of unique ‘cargo internalization receptors’ (CIR) for specific cell tracking. A nanobody for green fluorescent protein (GFP) was used to engineer surface receptors which undergo rapid internalization after GFP binding. For 19F MR visibility, the GFP carrier was equipped with perfluorocarbon (PFC) contrast cargo. PFC cargo uptake after CIR transfection was verified by flow cytometry, confocal microscopy, and 1H/19F MRI. The results show that this approach can be successfully used for targeted contrast agent internalization, which can be extended to a cell-specific CIR expression in transgenic mice for in vivo cell tracking by 19F MRI.

Characterization of Gd-DOTA-APC, a novel cancer-targeting MRI contrast agent

In this work we characterize the relaxivity, chemical stability, and tumor-specific uptake of a cancer-targeting T₂-shortening contrast agent, Gd-DOTA-APC. We observe striking longitudinal relaxivity of up to 16.5 s⁻¹/mM and 10.6 s⁻¹/mM at 1.5T and 3.0T, respectively. High chemical stability was measured, with less than 0.1% free Gd detected after dissolution of the agent in buffer. Finally, we observe tumor-specific T₂-weighted signal enhancement following Gd-DOTA-APC delivery, sustained out to seven days after administration. These observations indicate that Gd-DOTA-APC holds potential as a safe and effective agent for targeted cancer imaging.

CMRO₂ Quantification in Human Brain with Direct ¹⁷O-MRI: Profile Likelihood Analysis for Optimization of Temporal Resolution

In this study the temporal resolution of ¹⁷O-MRI protocols for quantification of the cerebral metabolic rate of oxygen consumption (CMRO₂) in human brain were optimized using the profile likelihood (PL) method. For this, retrospective analysis of the influence of temporal resolution on the CMRO₂ values and their PL-based confidence intervals (CI) was performed. Dynamic ¹⁷O-MRI was implemented with a 3D golden-angle radial acquisition during and after inhalation of ¹⁷O gas. The results showed that ¹⁷O-MRI data acquired at a temporal resolution 120≤Δt≤165 seconds gave identifiable CMRO₂ values of 0.82–1.18/0.92–1.42 µmol/g/min in WM/GM brain regions.

Region-Specific Effects of AMP-Activated Protein Kinase on the Neurochemical Profiles of the Hippocampus and Midbrain in Mice

Adenosine monophosphate-activated protein kinase (AMPK) is an evolutionarily conserved signaling molecule essential for cellular energy balance. AMPK senses metabolic stress and integrates diverse physiological signals to restore energy balance. Its role in the normal brain development is not well understood. The purpose of this study was to assess whether neurochemical profiles of developing mouse brain are affected by knocking out of AMPK enzyme in a region-specific manner. Observed changes in metabolite levels (Lac, Glu) indicate reduced energy metabolism in AMPK knockout mice relative to WT controls. In addition, changes in myo-Inos suggest osmotic stress.

Accelerated knee imaging using a deep learning based reconstruction

In this work we characterize the relaxivity, chemical stability, and tumor-specific uptake of a cancer-targeting T₂-shortening contrast agent, Gd-DOTA-APC. We observe striking longitudinal relaxivity of up to 16.5 s⁻¹/mM and 10.6 s⁻¹/mM at 1.5T and 3.0T, respectively. High chemical stability was measured, with less than 0.1% free Gd detected after dissolution of the agent in buffer. Finally, we observe tumor-specific T₂-weighted signal enhancement following Gd-DOTA-APC delivery, sustained out to seven days after administration. These observations indicate that Gd-DOTA-APC holds potential as a safe and effective agent for targeted cancer imaging.

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The goal of this study is to determine the diagnostic accuracy and image quality of a recently proposed deep learning based image reconstruction for accelerated MR examination of the knee. 25 prospectively accelerated cases were evaluated by three readers and show excellent concordance to the current clinical gold standard in identification of internal derangement.

Plasma 2

Anterior Tibial Translation Following ACL Reconstruction is Associated with Postsurgical Cartilage Matrix Changes.
Alan K Li¹, Valentina Pdeo², Keiko Armano³, Jonathan Ochoa¹. Qi Li², Benjamin Ma¹, and Xiaojuan Li²
¹University of California, Berkeley, Berkeley, CA, United States, ²University of California, San Francisco, San Francisco, CA, United States

Biomechanical abnormalities and accelerated cartilage matrix changes are commonly seen following ACL injury; however, the association between the two remains unclear. The purpose of this study was to analyze the relationship between altered joint kinematics and long term cartilage health. Utilizing voxel based relaxometry with T₁W and T₂ mapping sequences, in conjuction with MRI kinematics of the tibia and femur bone, allowed for the assessment of local cartilage matrix changes 2 years following ACL reconstruction. Notably, anterior translation of the tibia in the injured knee was associated with greater cartilage degeneration in the medial femoral and tibial cartilage.

Plasma 3

Longitudinal characterization of deformation-induced skeletal muscle damage by T2-mapping, DWI and MRE
Jules L. Nelissen¹,², Willeke A. Traa³, Larry de Graaf³, Cees W. J. Oomens⁴, Jurgen H. Runge³, Ralph Sinkus⁴, Klaas Nicolay⁴, Aart J. Nederveen¹, Martijn Froeling³, and Gustav J. Strijkers²
¹Biomedical NMR, Eindhoven University of Technology, Eindhoven, Netherlands, ²Preclinical and Translational MRI, Academic Medical Center, Amsterdam, Netherlands, ³Biomechanics of Soft Tissues, Eindhoven University of Technology, Eindhoven, Netherlands, ⁴Division of Imaging Sciences & Biomedical Engineering, King's College London, London, United Kingdom, ⁵Radiology, Academic Medical Center, Amsterdam, Netherlands, ⁶Department of Radiology, University Medical Center Utrecht, Utrecht, Netherlands

Skeletal muscle injury is often accompanied by fibrosis, fatty infiltration, and edema. There is great need for imaging readouts to detect and quantify such compositional changes, which would aid understanding and greatly assist in the development of emerging therapies. The goal of this work was to use a multi-modality approach, combining magnetic resonance elastography (MRE; muscle stiffness, fibrosis) with diffusion-weighted imaging (DWI; myocyte integrity) and T₂-mapping (edema, inflammation) to provide a comprehensive assessment of muscle injury development and regeneration. The multi-modality assessment provided differential readouts of the deformation-induced muscle injury development and regeneration process.

Plasma 4

Age Related Differences in Shear Strain in Medial Gastrocnemius: Implications for Lateral Transmission of Force
Vadim Malis¹, Usha Sinha², Robert Csapo², and Shantanu Sinha²
¹Physics, UC San Diego, San Diego, CA, United States, ²Physics, San Diego State University, San Diego, CA, United States, ³Radiology, UC San Diego, San Diego, CA, United States

The disproportionate loss of muscle force in comparison to loss of muscle mass with age remains unexplained. Recent studies indicate that the remodeling of the extracellular matrix (ECM) may disrupt lateral force transmission pathways mediated by the ECM. Shear strain is the mechanism that supports lateral transmission of force. We quantified shear strain in muscle from the strain rate tensor derived from velocity encoded phase contrast dynamic images of the in-vivo human calf muscle under isometric contractions. The maximal shear strain was significantly lower in the older cohort compared to the younger cohort which potentially identifies that lateral force transmission decreases with age.

Plasma 5

Metal Artifact Reduction MRI for the Assessment of the Rotational Alignment Knee Arthroplasty Implants: Compressed Sensing SEMAC TSE versus High-Bandwidth MRA
Filippo Del Grande¹,², Benjamin Fritz³, Sarel Stelker¹, Steven E Stern¹, Susanne Benster³, and Jan Fritz¹
¹Radiology, The Johns Hopkins University School of Medicine, Baltimore, MD, United States, ²Radiology, Ospedale Regionale di Lugano, Lugano, Switzerland, ³University Hospital Balgrist, Zurich, Switzerland, ⁴Radiology, The Johns Hopkins University School of Medicine, Baltimore, MD, ⁵Queensland University of Technology, Brisbane, Australia

Malrotation of knee arthroplasty implants is a source of pain following total knee arthroplasty and may be assessed on metal artifact reduction MR images; however, it is unclear how well MRI can identify this condition. Therefore, we compared the reliability, repeatability, and precision of rotational alignment measurements that were obtained on optimized high-bandwidth and conventional SEMAC TSE MR images and their relationships with symptoms. CS-SEMAC TSE MRI afforded the highest reliability, repeatability and precision of rotational alignment which correlate best with symptoms. CS-SEMAC TSE MRI may be preferred over high-BW TSE for rotational alignment measurements of knee arthroplasty implants.

Plasma 6

Ability of MAVRIC MRI to Predict Component Loosening in Total Hip Arthroplasty
Alissa Jo Burge¹, Gabrielle P Konin¹, Jennifer Berkowitz¹, Matthew Koiff², Douglas Pudget², and Hollis Potter¹
¹Radiology and Imaging, Hospital for Special Surgery, New York, NY, United States, ²Adult Reconstruction and Joint Replacement, Hospital for Special Surgery, New York, NY, United States
Improved metal reduction techniques for conventional MRI pulse sequences and the addition of MAVRIC (multiacquisition variable resonance image combination) have been established as useful in assessing component osteolysis and synovial reactions. The purpose of this retrospective study was to determine the utility of MRI in assessing loosening of total hip arthroplasty in a cohort of patients using surgical confirmation of loosening as the gold standard. Our results show that loosening can be predicted with high sensitivity and specificity; however, intraoperative variability in assessing loosening and the overall low frequency of implant loosening are limiting factors.

651 Plasma 7 Simultaneous multi-slice TSE for clinical MR Imaging of lesions in the knee
Xiaona Li, Zhigang Peng, Yi Sun, Panli Zuo, Dingxin Wang, and Janting Cui

To introduce simultaneous multiple slices (SMS) turbo spin echo (TSE) and to evaluate its image quality and diagnostic accuracy for lesions in the knee. Participants were examined by SMS and routine TSE sequences. Both sequences were evaluated by three radiologists with subjective and objective scores in T1- and PD-weighted images. The diagnostic value in lesions was evaluated. SMS requires less scan time and offers similar imaging quality and diagnostic rate compared to routine TSE sequence. SMS is a valuable technique for MR examination of the knee.

652 Plasma 8 Simultaneous T2 Relaxometry and Morphometry of Cartilage and Meniscus with Double-Echo in Steady-State in Five Minutes
Akhay S Chaudhari, Marianne S Black, Bragi Sveinsson, Garry E Gold, and Brian A Hargreaves

Quantitative MRI parameters such as T2 relaxation times and morphometry are potential biomarkers for tracking spatial and temporal changes in musculoskeletal diseases and injuries. While cartilage has been widely studied, the short-T2 of meniscus makes it challenging to quantify in short scan times. In this study, we optimized the double-echo steady-state (DESS) pulse sequence to produce high-resolution and high signal-to-noise ratio images in five minutes. We compared the relaxometry and morphometry measures against established methods and found no significant differences. This suggests that a five-minute DESS scan could be used for simultaneous relaxometry and morphometry of the cartilage and meniscus.

653 Plasma 9 Soft Tissue Tumors: Use of Intravoxel Incoherent Motion MR Imaging for Assessment of Diffusion and Perfusion for the Differentiation of Benign from Malignant Tumors
Haijun Wu and Changhong Liang

The apparent diffusion coefficient (ADC) had better diagnostic performance than other Intravoxel incoherent motion (IVIM)-derived parameters did for differentiating malignancies from benign soft-tissue tumors. The f values of intermediate soft-tissue tumors are significantly lower than those of benign and malignant soft-tissue tumors. The combination of ADC and f values is significantly better than other IVIM parameters at differentiating soft-tissue tumors.

654 Plasma 10 1-year Follow-Up of T1ρ for Assessing Radiocarpal Cartilage Matrix Changes after Anti-TNF treatment for Rheumatoid Arthritis: Preliminary Results
Eric Ku, Valentina Pedroia, Matthew Tanaka, Hyo Jin Chu, Ursula Heilmeier, Andrew Burghardt, Jonathan Graf, John Imboden, Thomas Link, and Xiaojuan Li

MR T1ρ is used to investigate biochemical changes in cartilage composition, but few studies have looked at its application in radiocarpal wrist cartilage. In this study, we assessed 1-year changes in T1ρ following rheumatoid arthritis treatment and its relationship with changes in clinical disease activity scores and patient-reported outcomes. Changes between 1-year and baseline T1ρ values correlated significantly with disease activity score changes and approached significance with patient-reported outcome changes during the same period. Changes in T1ρ values at 3-months also correlated significantly with 1-year changes in metacarpophalangeal and wrist bone erosion volume measured with high-resolution peripheral quantitative CT (HR-pQCT).

655 Plasma 11 Simultaneous Multi-Slice Accelerated High Resolution MRI of the Knee: Comparison with In-plane Parallel Imaging Acceleration
Jan Fritz, Benjamin Fritz, Jialu Zhang, D. Dharmve H Joshi, Gaurav K Thawal, Li Pan, and Dingxin Wang

Simultaneous multi-slice acceleration techniques excite, acquire, and reconstruct multiple slices simultaneously and provide the potential to create substantially accelerated clinical TSE protocols with similar spatial and contrast resolution to current TSE protocols. We quantified the signal-to-noise and contrast-to-noise ratios of various combinations of parallel and simultaneous multi-slice acceleration and compared two 4-fold accelerated TSE protocols against a clinical 2-fold accelerated TSE standard. Our results demonstrate that 4-fold TSE acceleration enables 43-60% shorter acquisition times with similar image quality, structural visibility and observer satisfaction than standard parallel imaging acceleration.

656 Plasma 12 New insights into the predilection sites of Juvenile Osteochondritis Dissecans using Quantitative Susceptibility Mapping
The unique utilization of tissue-inherent MRI contrast using QSM for depicting the intraepiphyseal vascular supply provides high resolution and accuracy without using exogenous contrast making it a noninvasive tool for future in vivo studies. A better understanding of the development of the epiphyseal cartilage vascularity during skeletal maturation may shed light on the etiology of many developmental diseases, such as Juvenile Osteochondritis Dissecans that are precursors to osteoarthritis.

Pile up correction for 3D-Multi Spectral Imaging using Gaussian Spectral Modeling and Bin Expansion

Jutta Ellermann1, Casey P. Johnson1, Luning Wang1, Ferenc Toth1, Kevin Shea3, Cathy Carlson6, and Mikko J Nissi2,7

1Radiology, University of Minnesota, Minneapolis, MN, United States, 2Radiology, CMRR, University of Minnesota, 3College of Veterinary Medicine, University of Minnesota, 4St. Luke's Orthopaedics, Boise, ID, 5College of Veterinary Medicine, University of Minnesota, St. Paul, MN, 6Department of Applied Physics, University of Eastern Finland, 7Diagnostic Imaging Center, Kuopio University Hospital, Kuopio, Finland

The difficulty of imaging around metal implants has been overcome using pulse sequences such as MAVRIC SL and SEMAC. While the images are largely artifact-free, subtle intensity fluctuations, or ‘pile up’ artifacts still remain. The post-processing approach presented here uses information extracted from a spectral-domain model to identify and correct local fluctuations in image intensity. In these regions, the spectral bins are expanded using a moving average filter. When the expanded bins are combined, the pile up is significantly reduced. This pile up correction can improve the aesthetic quality of the images, and significantly improve their diagnostic ability.

Correlation Time Mapping of Articular Cartilage: correlation with tissue composition and structure

Correlation time ($\tau_c$) is a physical property of the tissue that describes the dynamics of water molecules in their microenvironment. In this study, $\tau_c$ is obtained from enzymatically digested bovine samples. To evaluate the relationship between $\tau_c$ and macromolecular components of cartilage, depth-wise $\tau_c$ profiles were correlated with quantitative histological measurements. The same comparison was performed for T2 data. Our results suggest that $\tau_c$ is sensitive to the laminary architecture of cartilage and to the proteoglycan content in the radial zone. $\tau_c$ provides complementary information to conventional T2 mapping.

Correlation of 7T gagCEST MRI with Electromechanical and Biochemical Properties of Femoral Articular Cartilage

Sander Brinkhof1, Razmara Nizak2, Sotcheadt Sim3, Vitaliy Khlebnikov1, Dennis Klomp1, and Daniel Saris1,4

1Radiology, University Medical Center Utrecht, Utrecht, Netherlands, 2Orthopaedics, University Medical Center Utrecht, Utrecht, 3Biomomentum Inc., Laval, QC, Canada, 4MIRA Institute for Biomedical Technology and Technical Medicine, University of Twente, Enschede, Netherlands

The purpose of this study was to validate the 7T 3D gagCEST measurements obtained in patients in vivo, using correlation of MRI GAG values with electromechanical mapping of the articular cartilage and biochemical analyses. Five patients were scanned before their total knee replacement, after which the extracted cartilage samples were used for electromechanical and biochemical analyses. GAG content as determined by gagCEST MRI shows to be significantly correlated with biochemically measured GAG dry weight and with electromechanical mapping. This work shows that the electromechanical properties of cartilage are correlated with gagCEST MRI values.

Poster: Cancer Imaging in the Body

Exhibition Hall Wednesday 9:15 - 10:15

Interobserver Agreement and Diagnostic Performance of LI-RADS v2014 on contrast-enhanced MRI for non-HCC malignancies

Nataly de Souza Maciel Rocha Horvat1, Ines Nikolovski1, Niamh Long1, Scott Gerst1, Jian Zheng1, Linda Ma Pak3, Junting Zheng1, Lorenzo Mannelli2, and Richard Kinh Gian Do1

1Memorial Sloan Kettering Cancer Center, NY, NY, United States

Patients at risk for hepatocellular carcinoma (HCC) are often also at risk for intrahepatic cholangiocarcinoma (ICC) and combined hepatocellular cholangiocarcinoma (cHCC-ICC). The purpose of this study was to evaluate the sensitivity and specificity of MRI in 4 radiologists using LI-RADS v2014 and their inter-reader agreement for diagnosing non-HCC malignancies (ICC and cHCC-ICC). Applying LI-RADS v2014, we found sensitivities between 74% to 88% for the diagnosis of non-HCC malignancies with moderate to substantial inter-reader agreement for LI-RADS category as LR-M or non LR-M. However, lower sensitivity was seen for smaller tumors, which are known to overlap with HCC in imaging appearance.
Plasma 17  

**Quantification of hepatocellular carcinoma tumor heterogeneity with multiparametric MRI**

**Stefanie Hectors**, Mathilde Wagner, Octavia Bane, Cecilia Besa, Sara Lewis, Romain Remark, Nelson Chen, M. Isabel Fiel, Hongfa Zhu, Sacha Grjijevic, Miriam Merad, Yujin Hoshida, and Bachir Taouli

Translationally and Molecular Imaging Institute, Icahn School of Medicine at Mount Sinai, New York, NY, United States. 1Department of Radiology, Icahn School of Medicine at Mount Sinai, New York, NY, United States, 2Immunology Institute, Icahn School of Medicine at Mount Sinai, New York, NY, United States, 3Department of Pathology, Icahn School of Medicine at Mount Sinai, New York, NY, United States, 4Oncological Science, Icahn School of Medicine at Mount Sinai, New York, NY, United States, 5Department of Medicine/Division of Liver Diseases, Icahn School of Medicine at Mount Sinai, New York, NY, United States

We assessed tumor heterogeneity in hepatocellular carcinoma using multiparametric MRI (mpMRI) combining DWI, BOLD-MRI, TOLD-MRI and DCE-MRI measurements. Histogram characteristics (central tendency parameters mean and median and heterogeneity parameters standard deviation, kurtosis and skewness) of mpMRI data were quantified in the lesions and correlated between MRI methods and with histopathology and gene expression levels in a subset of patients. We observed that central tendency and heterogeneity parameters were largely complementary in terms of the assessed correlations. The proposed histogram analysis is therefore promising for noninvasive HCC characterization on the functional, immunohistochemical and genomics level.

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Plasma 18  

**3D MR Elastography in Prediction of Tumor Capsule Formation of Hepatocellular Carcinoma (HCC) in Patients with Hepatitis B Virus Infection**

**Jia Xu**, Hao Yang, Yong Liu, Jingbiao Chen, Tianhui Zhang, Kevin J. Glaser, Xin Li, Jun Chen, Yao Zhang, Qiangfeng Shan, Bingjun He, Zhugang Gu, Yin Meng, Dzyubak Bogdan, Venkatesh SK, Ronghua Yan, Xi Long, and Richard L. Ehman

1Department of Radiology, the Third Affiliated Hospital, Sun Yat-sen University (SYSU), Guangzhou, People’s Republic of China, 2Department of Pathology, the Third Affiliated Hospital, Sun Yat-sen University (SYSU), Guangzhou, People’s Republic of China, 3Department of Radiology, Mayo Clinic, Rochester, United States, 4GE Healthcare MR Research China, Guangzhou, People’s Republic of China

Hepatocellular carcinoma (HCC) is one of the leading causes of cancer-related deaths around the world. Tumor capsule formation is a significant and independent predictor of survival and recurrence. We explored the potential value of HCC stiffness using 3D MR elastography for the prediction of tumor capsule formation. Results in 50 examinations showed that stiffness promise is high for the preoperative prediction of tumor capsule formation, thus providing motivation for further evaluation of HCC characteristics with MRE.

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Plasma 19  

**Dynamic Contrast Enhanced MR Imaging of Hepatopancreatobiliary lesions in Combined use of Parallel Imaging and Compressed Sensing**

**Takayuki Masui**, Motoyuki Katayama, Yuji Iwadate, Naoyuki Takei, Kang Wang, Kevin King, Kei Tsukamoto, Mitsuteru Tsuchiya, Yuki Hayashi, Masako Sasaki, Takahiro Yamada, Kenichi Mizuki, Harumi Sakahara, Koji Yoneyama, and Yuki Takayanagi

1Radiology, Seirei Hamamatsu General Hospital, Hamamatsu, Japan, 2Global MR Applications and Workflow, GE Healthcare Japan, Hino, Japan, 3Global MR Applications and Workflow, GE Healthcare, Madison, WI, United States, 4Global MR Applications and Workflow, GE Healthcare, Waukesha, WI, United States, 5Radiology, Hamamatsu University School of Medicine, Hamamatsu, Japan

The feasibility of dynamic Gd-contrast study using turbo LAVA with ARC and CS for evaluation of pancreaticobiliary lesions was evaluated. Acceptable image quality and good temporal resolutions with selective recognition of vasculatures, and lesion detections in the liver and pancreas could be made. With this technique, dynamic contrast imaging with high temporal and spatial resolutions can cover the wide area. It takes acceptable time for image reconstruction with ARC and CS at clinical 3T MR unit.

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Plasma 20  

**Detection and measurement of neuroendocrine tumors liver metastases using Gd-EOB-DTPA enhanced MRI: comparison between multiple arterial phases, hepatobiliary phase, and DWI**

**Jia Xu**, Xuan Wang, Hua dan Xue, Shi tian Wang, Hui Liu, and Zheng yu Jin

1Department of Radiology, Peking Union Medical College Hospital, Beijing, People’s Republic of China, 2Siemens Ltd, Shanghai, People’s Republic of China

The detection and evaluation of liver metastasis (LM) is important in initial staging and follow-up examinations of neuroendocrine tumors patients. Our aim is to compare different sequences including multiple arterial phases (MA), hepatobiliary phase (HB), diffusing-weighted imaging (DWI), and T2WI in Gd-EOB-DTPA-enhanced MRI, to find which sequence is better for detecting LM and which is better for size measurement. MA using CDT-VIBE were superior for the detection of small lesions. HB imaging shows better repeatability in size measuring and may be a better choice for lesion size measurement during follow-up.

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Plasma 21  

**Integrated slice-specific shimming (iShim) intravoxel incoherent motion diffusion-weighted MR imaging in the liver: the value of differential diagnosis between benign and malignant hepatic tumors**

**Hongxia Wang**, Qingbo Li, Bin Wang, Qingli Shi, Yan Feng, Xingyue Jiang, and Peigong Zhang

1Radiology Department, Binzhou Medical University Hospital, Binzhou, People’s Republic of China, 2Emergency Department, Binzhou People’s Hospital, Binzhou, People’s Republic of China, 3Binzhou Medical University, Yantai, People’s Republic of China, 4MR Scientific NE Asia, Siemens Healthcare, Beijing, People’s Republic of China

This study investigated the value of ADC value, D, Dstar, ADC500-800 acquired with prototype iShim sequence at 3T. All those parameters demonstrated high diagnostic capacity in distinguishing benign and malignant hepatic lesions and in distinguishing different types of malignant hepatic lesions, among which ADC500-800 demonstrated the best diagnostic performance, which may have great value in clinical practice in future.

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Plasma 22  

**Quantitative texture feature to predict Microscopic portal vein invasion of Hepatocellular carcinoma with contrast-enhanced MR images**
Plasma 23
Conductivity of different malignancy grades of invasive ductal carcinomas and fibroadenomas
Ulrich Katscher1, Mussa Gagiyev1, Naoko Mori1, Keiko Tsuchiyah1, Jochen Keupp1, and Hiroki Abe1
1Philips Research Europe, Hamburg, Germany, 1Tohoku University, Sendai, Japan, 2Shiga University, Hikone, Japan, 3University of Chicago, IL, United States

In ex vivo studies, breast tumors exhibit a significantly altered electric conductivity, measurable in vivo using “Electric Properties Tomography”. A significant conductivity difference was reported between benign and malignant breast tumors and between invasive and in situ carcinomas. This study tested a correlation between conductivity and WHO grade of invasive ductal carcinomas (IDCs) and benign fibroadenomas. Clear conductivity differences were found between IDC grade 1 and grade 2, as well as between IDC grade 1 and grade 3. No clear difference was found between fibroadenoma and IDC grade 1, as well as between IDC grade 2 and grade 3.

Plasma 24
A computer aided diagnosis (CAD) scoring tool: prostate cancer risk evaluation with PI-RADS v2 Guidelines
Lian Ding1, Ge Gaoling1, Yajing Zhang1, Chengyang Wang1, Jue Zhang1, Xiaoying Wang1, and Jing Fang1
1Academy for Advanced Interdisciplinary Studies, Peking University, Beijing, People’s Republic of China, 2Department of Radiology, Peking University Frist Hospital, Beijing, People’s Republic of China, 3Philips Healthcare, Suzhou, China, Beijing, People’s Republic of China, 4College of Engineering, Peking University, Beijing, People’s Republic of China

The second version of the Prostate Imaging Reporting and Data System (PIRADSv2) indicates the likelihood of a clinically significant cancer with a simplified 5-point scale. To assist radiologists in making diagnostic decisions consistent with the PIRADSv2, we proposed a machine learning-based computer aided diagnosis (CAD) scoring tool of prostate cancer risk evaluation by combining apparent diffusion coefficient (ADC) and T2-weighted MRI-based features. The tool could provide a malignancy prediction color map of 5 scores. The statistical results of the total score test for 130 patients between radiologist graded and the CAD tool showed high accuracy and AUC.

Plasma 25
Deep learning to improve prostate cancer diagnosis
Nikolaos Dikaios1, Edward W Johnston2, Harbir S Sidhu2, Mishta B Appaya2, Alex Freeman2, Hashim U Ahmed2, and Shonil Punwani2
1Electrical Engineering, University of Surrey, Guildford, United Kingdom, 2Centre for Medical Imaging, University College London, 3Histopathology, University College London, 4Surgery and Interventional Science, University College London

Multiparametric MRI (mp-MRI) can localize tumors within the prostate, guide biopsy, and assess disease burden. Nevertheless, mp-MRI itself remains imperfect. Almost 40% of mp-MRI studies are reported as indeterminate for significant cancer. An indeterminate mp-MRI confers no patient benefit; such patients require either repeat interval mp-MRI and/or subsequent biopsy. There remains a clear unmet need to improve diagnostic imaging over and above standard mp-MRI protocols. In this pilot study we have acquired and analyzed LWI, DWI, and DCE-MRI data from 15 patients to compare the diagnostic accuracy of LWI with the other two techniques. Our results show that LWI provides equal or higher accuracy in detection of tumors and better correlation with tumor grade compared to DWI and DCE-MRI.
Precision medicine is increasingly being used in radiological applications. Advanced machine learning coupled with informatics modeling of clinical and radiological variables can provide the foundation to relate to precision medicine in patients with prostate cancer. We test our modeling using multiparametric prostate MR imaging (mpMRI) and MR-guided prostate biopsy with magnetic resonance-transrectal ultrasound (MR-TRUS) fusion to correlate the imaging features with histopathological results.

This study combines radiographic images and pathological microscopy with machine learning to generate predictive maps of pathological features (i.e. new contrasts) based on segmented histological features. Predictive cytological topography (PiCT) maps of cellularity were utilized to detect additional pathologically confirmed high-grade prostate cancer tumors missed by radiologists.

There is an increasing interest on whether IVIM parameters can be used as surrogates of perfusion and thus complement information on tumor microstructure. DCE-MRI techniques on the other hand have been widely used to characterise perfusion and hence offer the opportunity to test this hypothesis. In this study, we use high temporal resolution DCE-MRI and IVIM-DWI techniques to monitor patients with advanced breast cancer at various stages of their neoadjuvant chemotherapy, and assess the physiological relationship between perfusion and IVIM parameters.

Electronic Power Pitch Poster

Poster: RF Arrays & Systems

**Plasma 28**

**Predictive Cytological Topography (PiCT): a Radiopatmics Approach to Mapping Prostate Cancer Cellularity**

Amy Kaczmarowski1, Kenneth A Iczkowski2, Sarah L Hurrell1, Sean D McGarry1, Kenneth Jacobsohn1, William A Hall1, Mark Hohenwalter1, William See1, and Peter S LaViolette1

1Radiology, Medical College of Wisconsin, Milwaukee, WI, United States, 2Pathology, Medical College of Wisconsin, Milwaukee, WI, United States

This study combines radiographic images and pathological microscopy with machine learning to generate predictive maps of pathological features (i.e. new contrasts) based on segmented histological features. Predictive cytological topography (PiCT) maps of cellularity were utilized to detect additional pathologically confirmed high-grade prostate cancer tumors missed by radiologists.

**Plasma 29**

**Estimating breast tumor blood flow and blood volume using MRI: DCE vs IVIM**

Leonidas Georgiou1, Nisha Sharma1, Daniel Wilson1, and David L Buckley1

1Division of Biomedical Imaging, University of Leeds, Leeds, United Kingdom, 2Department of Radiology, Leeds Teaching Hospital NHS Trust, 3Department of Medical Physics and Engineering, Leeds Teaching Hospital NHS Trust

There is an increasing interest on whether IVIM parameters can be used as surrogates of perfusion and thus complement information on tumor microstructure. DCE-MRI techniques on the other hand have been widely used to characterise perfusion and hence offer the opportunity to test this hypothesis. In this study, we use high temporal resolution DCE-MRI and IVIM-DWI techniques to monitor patients with advanced breast cancer at various stages of their neoadjuvant chemotherapy, and assess the physiological relationship between perfusion and IVIM parameters.

**Plasma 30**

**Discrimination of Malignant versus Benign Mediastinal Lymph Nodes Using Diffusion MRI with An IVIM Analysis**

Li-Ping Qi1,2, Wan-Pu Yan1, Ke-Neng Chen1, Zheng Zhong1,4, Keja Cai1,2, Xiao-Ting Li1, Ying-Shi Sun1, and Xiaohong Joe Zhou1,2

1Radiology, Peking University Cancer Hospital and Institute, Beijing, People's Republic of China, 2Center for MR Research, University of Illinois at Chicago, Chicago, IL, United States, 3Thoracic Surgery, Peking University Cancer Hospital and Institute, Beijing, People's Republic of China, 4Bioengineering, University of Illinois at Chicago, Chicago, IL, United States

Noninvasive discrimination of mediastinal lymph nodes (MLN) is crucial for management of cancer patients such as those with non-small cell lung carcinoma. This study aims at investigating the value of IVIM diffusion parameters (D, D*, and f) as well as ADC for discrimination of malignant and benign MLN. A total of 91 MLN from 35 patients with histopathologic proven lesions were studied. D and f of malignant mediastinal lymph nodes were significantly different from those in the benign ones. The combination of f and D produced the highest diagnostic performance as evaluated by a receiver operating characteristic (ROC) analysis.

**Plasma 1**

**Development and Clinical Implementation of Very Light Weight and Highly Flexible AIR Technology Arrays**

Shreyas S Vasawada1, Robert Storment2, Scott Lindsay2, Thomas Grafendorfer2, Joseph Y Cheng3, John M Pauly4, Michael Lustig5, Greig Scott1, Jorge X Guzman1, Victor Taracila1, Daniel Chirayath2, and Fraser Robb2

1Radiology, Stanford University, Stanford, CA, United States, 2GE Healthcare, 3Electrical Engineering, Stanford University, 4Electrical Engineering and Computer Science, UC Berkeley

Pediatric body MRI faces challenges of widely varying patient sizes, heterogeneous imaging indications, and limited patient cooperation. These difficulties are compounded by receiver array coils that are often mismatched to patients' size. In this work, we develop a novel light-weight flexible coil array that can be placed on a patient, and combined with a high-density posterior array and determine feasibility of clinical use in a pediatric setting. The resulting coil is well received in the clinic and yields good image quality.

**Plasma 2**

**The Optimality Principle for MR signal excitation and reception: new physical insights into ideal RF coil design**

Daniel K. Sodickson1,2, Riccardo Lattanzi1,2, Manushka Vaidya1,2, Gang Chen1,2, Dmitry S. Novikov1,2, Christopher M. Collins1,2, and Graham C. Wiggins1,2

1Radiology, Stanford University, Stanford, CA, United States, 2GE Healthcare, 3Electrical Engineering, Stanford University, 4Electrical Engineering and Computer Science, UC Berkeley

Pediatric body MRI faces challenges of widely varying patient sizes, heterogeneous imaging indications, and limited patient cooperation. These difficulties are compounded by receiver array coils that are often mismatched to patients' size. In this work, we develop a novel light-weight flexible coil array that can be placed on a patient, and combined with a high-density posterior array and determine feasibility of clinical use in a pediatric setting. The resulting coil is well received in the clinic and yields good image quality.
Despite decades of collective experience, RF coil optimization has remained a largely empirical process, with clear insight into what might constitute truly task-optimal, as opposed to merely "good," coil performance being difficult to come by. We introduce a new principle, the Optimality Principle, which allows one to predict the form of signal-optimizing current patterns on any arbitrary surface, using a simple conceptual framework. After a brief derivation of the principle, we illustrate its use in generating ideal current patterns for various experimental conditions, and in understanding the emergence of electric dipoles as strong performers at high frequency.

RF arrays with large numbers of independent elements are desirable for parallel imaging and transmission. However, electromagnetic (EM) coupling between elements becomes significant as the number of coils increases and can severely impact coil performance. Several methods such as overlapping elements, L/C networks and auxiliary resonators have been proposed to reduce coupling, and are effective in decoupling adjacent elements, but are usually less effective for non-adjacent elements, and are not directly applicable to recently-proposed mixed arrays such as combinations of dipoles/monopoles and loop arrays. To address these problems, we propose a simple, geometry-independent self-decoupled RF coil design in which the two induced current modes in a loop coil can be adjusted to cancel each other. The method is validated in EM simulations, bench tests and MR experiments.

Optically Controlled Four-Channel Transceiver for 7T imaging with RF Monitoring Feedback
Natalia Gudina, Jacco A de Zwart, Peter van Gelderen, and Jeff H Duyn

In multi-channel RF transmission, monitoring and accurate control of amplitude and phase of the transmit signal is necessary to ensure safety. To this end, we present a four-channel transceiver array for 7T imaging built from optically-controlled on-coil amplifiers with optical real-time RF signal monitoring. Based on this monitoring signal an amplitude and phase control can be implemented for flexible, accurate and rapid control of B1 and SAR.

Double-Row 16-element Tight-Fit Transceiver Phased Array with High Transmit Performance for Whole Human Brain Imaging at 9.4T.
Nikolai I. Avdievich, Ioannis A. Giapitzakis, and Anke Henning

At ultra-high fields (UHF >7T) a simple increase of the length of a single-row human head transmit (Tx) phased array cannot provide an adequate longitudinal coverage for the whole brain imaging. Multi-row (>2) arrays together with RF shimming have to be used instead. In this work, we constructed a 9.4T (400 MHz) 16-loop double-row transceiver array based on the analytical modeling. We demonstrated that simply by overlapping a very good decoupling can be obtained without additional decoupling strategies. This provides a recipe of a simple, robust, and very Tx-efficient design for parallel transmission and whole brain imaging at UHFs.

Compact iPRES coil assembly for Magnetic Resonance Fingerprinting
Michael Twieg, Bhairav B Mehta, Simone Coppo, Haoqin Zhu, Labros Petropoulos, Hiroyuki Fujita, and Mark A Griswold

Magnetic Resonance Fingerprinting (MRF) makes use of spatially and temporally incoherent encoding schemes to produce orthogonal signals from different tissues. Here we present a coil optimized for MRF that integrates parallel receive, excitation, and shimming (iPRES) to provide an ideal method of modulating all three available magnetic fields (B0, B1, and ΔB0). In order to be useful in quantitative imaging, an iPRES array must convey these fields accurately, and cost effectively. Here we demonstrate an iPRES coil element with all three field amplifiers located on-coil, providing improved sensitivity and efficiency relative to remote amplifiers.

Wireless coil based on meta-technologies for MRI implementations
Alena Shchelokova, Alexey Slobozhanyuk, Irina Melchakova, Andrew Webb, Yuri Kivshar, and Pavel Belov

We demonstrate experimentally how to improve the performance of MRI by employing wireless coil based on a hybrid tunable metasurface. We fabricate metasurface formed by an array of nonmagnetic metallic wires with high permittivity dielectric loads and investigate its in 1.5 T MRI machine. The metasurface enhances the SNR value in more than 7 times in the region of interest in comparison with the birdcage coil and 2 times versus the dedicated flat local coil.
We developed an RF-coil integrated DOI-PET insert for the 3T MRI system for human brain imaging. In this study we have given details of the second prototype system developed recently and evaluated performance for MRI-only, PET-only and simultaneous PET/MRI conditions. This system included 24 carbon fiber shielded PET modules which are positioned in between the coil-elements of a birdcage head-coil. In total 48 4-layer DOI detectors are included that gives 60 mm axial-FOV for PET imaging. Under all performance study the system worked quite well showing promise for near-future human brain study.

A new highly flexible RF coil design is described. Individual coil elements are constructed by means of a proprietary process that yields low reactance and low loss conductors while being lightweight, flexible, and durable. Phantom data indicate that for similar coil geometries, the coils provide equivalent SNR profiles but do not suffer from design limitations due to minimum coil overlap requirements of conventional copper coil elements. In vivo data demonstrate that these coils can be fabricated onto highly flexible and thin support materials that closely comply with anatomic contours in challenging imaging sites such as the c-spine.

A receive-only array of dielectric resonator antennas has been developed. A method for detuning the ceramic resonators is studied using simulations and measurements, after which a four-channel dielectric resonator antenna array is used for in vivo image acquisition of the ankle. Using this receive-only array allows for higher SNR and parallel imaging using SENSE.

In ultra-high-field brain MR imaging, the coverage for imaging with the optimized protocol is constrained not only by scan time, but also by the coil structure. Since presently available surface loop RF coils have limited field of view, it is very difficult to achieve the coverage from the top of the head to the end of the cervical vertebrae. Prior solution to this problem was to increase the number of elements. However, it increases the complexity of coil array design thus causing difficulties in construction of the coils. In this paper, an 8-channel top-hat dipole receive RF coil is proposed for the brain imaging at 7 Tesla MRI. By enabling the coil tuning with novel tuning methods for shorter RF coil lengths but still with reasonable uniformity and SNR for more imaging field of view compared with multi-element loop coils.

We propose a system that detects this change in resonance frequency. The system is integrated on a wearable MRI receiver of 20 x 30mm². The change in resonance frequency can be detected in-field. The detection works by sweeping an excitation current through a frequency range and measuring the frequency response. The frequency response is transmitted via a glass fibre to an out-field signal processing unit. Measurements were conducted using a stretchable liquid metal coil on neoprene.
Multimodal Imaging: MR-Compatible, Gradient Artifact free, Wireless recording system integrated with MR-scanner for Simultaneous EEG and fMRI acquisition

Ranajay Mandal1, Nishant Babaria2, Jayue Cao1, and Zhongming Liu1,2

1Biomedical Engineering, Purdue University, West Lafayette, IN, United States, 2Electrical and Computer Engineering, Purdue University, West Lafayette, IN, United States

The field of multimodal imaging has largely been propelled by two of the most widely used neuroimaging tools, fMRI and EEG, as the complementary nature of the two signals provides a unique avenue to evaluate the brain dynamics and its underlying neural circuitry. However, methodological challenges associated with simultaneous acquisition of EEG and fMRI impedes the method from achieving the full potential. To address these challenges, we present an MR-compatible, active recording system that utilizes surplus MR-hardware and inherent electromagnetic field to synchronize and wirelessly record gradient artifact free multichannel EEG signals and encode these Non-MR signals within the extended FOV of the MR image.

Mary had a little Lamb: Scanner-recorded speech during MRI without gradient-induced sound

Jan Ole Pedersen1,2, Christian Hansen, Rong Xue1, and Lars G. Hanson1,2

1Danish Research Centre for Magnetic Resonance, Centre for Functional and Diagnostic Imaging and Research, Copenhagen University Hospital, Kgs Lyngby, Denmark, 2Centre for Magnetic Resonance, DTU Elektro, Technical University of Denmark, Kgs Lyngby, Denmark, 3State Key Laboratory of Brain and Cognitive Science, Research, Institute of Biophysics, Chinese Academy of Sciences

During MRI, fast switching of imaging gradients generate loud noise of high intensity due to vibration of the gradient coils. The in-bore intercom used for patient communication is therefore typically turned off during scanning. This has implications for safety and image quality since patient speech and yells are not heard by the scanner operator. Using standard sequences, we demonstrate that sound can be recorded by MRI scanners and extracted from the scanners raw data, thereby enabling communication with patients for safety or experimental reasons.

### Poster: Post-Processing & Motion

#### Exhibition Hall
Wednesday 14:45 - 15:45

**Plasma 15**

**Multimodal Imaging: MR-Compatible, Gradient Artifact free, Wireless recording system integrated with MR-scanner for Simultaneous EEG and fMRI acquisition**

Ranajay Mandal1, Nishant Babaria2, Jayue Cao1, and Zhongming Liu1,2

1Biomedical Engineering, Purdue University, West Lafayette, IN, United States, 2Electrical and Computer Engineering, Purdue University, West Lafayette, IN, United States

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**Plasma 11**

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Jan Ole Pedersen1,2, Christian Hansen, Rong Xue1, and Lars G. Hanson1,2

1Danish Research Centre for Magnetic Resonance, Centre for Functional and Diagnostic Imaging and Research, Copenhagen University Hospital, Kgs Lyngby, Denmark, 2Centre for Magnetic Resonance, DTU Elektro, Technical University of Denmark, Kgs Lyngby, Denmark, 3State Key Laboratory of Brain and Cognitive Science, Research, Institute of Biophysics, Chinese Academy of Sciences

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**Plasma 16**

dBEaST: Cerebellar Brain Extraction based on Nonlocal Segmentation Technique – A comparison with state-of-the-art methods

Daniel Güllmar1, Viktor Pfaffenrot2, Rossitza Draganova3, Xiang Feng1, Jürgen R. Reichenbach1, Dagmar Timmann1, and Andreas Deistung1,2

1Medical Physics Group, Institute for Diagnostic and Interventional Radiology, Jena University Hospital – Friedrich Schiller-University, Jena, Germany, 2Section of Experimental Neurology, Department of Neurology, Essen University Hospital, Germany, 3Erwin L. Hahn Institute for Magnetic Resonance Imaging, University Duisburg-Essen, Essen, Germany

An automatic segmentation of the cerebellum is required to determine the cerebellar volume and for improving spatial normalization in voxel-based analysis approaches. While existing segmentation approaches typically work quite robust in healthy subjects, errors in segmentation increase with cerebellar atrophy and typically require manual corrections. We introduce a novel cerebellum segmentation approach, referred to as dBEaST, that relies on a dedicated multi-resolution segmentation library with manually edited cerebellar masks of both healthy and diseased subjects in combination with multi-atlas-propagation and segmentation as implemented in BEaST. Finally segmentation of the cerebellum with BEaST is compared with the alternative techniques SUIT and FreeSurfer.

**Plasma 17**

Signal-model-based water-fat separation in Zero Echo Time (ZTE) MRI

Romain Nicolas Froidevaux1, Markus Weiger1, Po-Jui Lu2, and Klaas Paul Pruessmann1

1University and ETH Zurich, Zurich, Switzerland, 2ETH Zurich, Zurich, Switzerland

The separation of water and fat in zero echo time (ZTE) imaging is challenging for several reasons: First, echo-based signal models are violated for fast-relaxing spins and require the use of loud sequences. Second, frequency selective preparation pulses produce large SAR and are inefficient on short-T2 compounds. Finally the off-resonance induced phase vanishes at TE = 0. In this work, we introduce the principles of a technique that allows water-fat separation for a single ZTE acquisition and demonstrate its potential and limits with phantom and in-vitro experiments.
Suspicious Component Segmentation for Identifying Hippocampal Sclerosis Using Regularized Tissue-Fraction MR Fingerprinting

Kang Wang1, Congyu Liao2, Xiaoli Cao2, Zhixing Wang2, Dengchang Wu1, Hongjian He1, Qiuping Ding2, and Jianhui Zhong2

1Department of Neurology, The First Affiliated Hospital, School of Medicine, Zhejiang University, Hangzhou, People’s Republic of China, 2Center for Brain Imaging Science and Technology, Department of Biomedical Engineering, Zhejiang University, Hangzhou, People’s Republic of China

A relaxometry-based tissue fraction segmentation using MR fingerprinting method was applied for identifying hippocampal sclerosis. The results demonstrated that tissue-fraction MR fingerprinting method could effectively segment multiple tissue components and mark the possible sclerosis regions, which is critical for clinical application including lesions diagnosis and multicompontent analysis.

Improved Short-T2* Estimation with Bloch Equation-Modeled Concurrent Excitation and Relaxation

Ethan M Johnson1, Kim Butts Pauly2, and John M Pauly2

1Electrical Engineering, Stanford University, Stanford, CA, United States, 2Radiology, Stanford University, Stanford, CA, United States

Short-T2* magnetization (order of [0.1,1ms]) can relax appreciably during standard-rate excitation pulses, which can bias estimates of relaxation rates formed by fitting to observed signal decay. The effect can, however, be included in an updated model to improve T2* estimation for fast-relaxing signals. Here, a demonstration is presented.

Edge preserving upampling of image resolution in MRI

Marco Reisert1 and Elias Kellner1

1Dep. of Radiology, Medical Physics, University Medical Center Freiburg, Freiburg, Germany

In this work we present a simple and efficient postprocessing method to isotropify the imaging resolution of MRI imagery. In MRI anisotropic voxel sizes are quite common due to several reasons. Typically the trough-plane voxel size is higher than the in-plane resolution. We propose a simple technique to upsample to isotropic image resolution without introducing the typical block like artifacts known from conventional interpolation schemes.

Motion-compensated reconstruction of fetal cardiac MRI using a golden-angle radial acquisition, retrospective gating, and compressed sensing

Christopher W. Roy1,2, Mike Seed3, and Christopher K. Macgowan2,3

1Medical Biophysics, University of Toronto, Toronto, ON, Canada, 2Radiology and Experimental Medicine, Hospital for Sick Children, Toronto, ON, Canada, 3Pediatric Cardiology, Hospital for Sick Children, ON, Canada, 4Pediatric and Diagnostic Imaging, University of Toronto, Toronto, ON, Canada

Fetal cardiac MRI requires high spatial and temporal resolution but is often limited by stochastic and periodic motion. To compensate for these sources of artifact, a radial golden-angle acquisition was used to acquire and reconstruct real-time fetal cardiac images. In-plane motion and fetal heart rate were then calculated from the real-time images and used to reconstruct reordered CINE images at high spatial and temporal resolution. Using this approach, motion-robust imaging of the fetal heart was successful in seven pregnant volunteers for both short-axis and long-axis multi-slice acquisitions.

From Visualization to Quantification: Calibrating Motion Magnification by Amplified Magnetic Resonance Imaging

Wendy W Ni1, Maged Goubran1, Greg Zaharchuk1, M. Michael Moseley2, Kristen Yeom1, and Samantha Holdsworth1

1Radiology, Stanford University, Stanford, CA, United States

The brain is constantly in motion. Changes in the cardio-ballistic motion of brain structures can provide invaluable information on natural processes and pathology. We have previously introduced a qualitative visualization technique, Amplified MRI (aMRI), to amplify subtle cardio-ballistic motion in the brain. Now we attempt to quantify the underlying motion through simulation-based characterization of the aMRI technique. By generating calibration curves for a range of motion parameters, we calculated the unamplified tissue displacement in two human subjects. The estimated displacements are higher than literature values. Nevertheless, our simulations are the first steps in benchmarking aMRI’s potential as a quantitative technique.

Assessing the effect of head-motion on tissue volume estimates

Daniel Gallichan1,2

1School of Engineering, Cardiff University, Cardiff, United Kingdom, 2EPFL- CIBM, Lausanne, Switzerland

We looked at data from 60 subjects undergoing 1mm resolution T1-weighted structural scans at 7T with 3D FatNavs allowing retrospective motion-correction. Motion parameters for 60 subjects were examined for general trends – and typical motion was dominated by translation in the z-direction and a small backwards rotation of the head. Quantitative estimates of tissue volumes were compared before and after motion-correction was applied, suggesting that total intracranial volume tends to be overestimated when the subject moves more – and that this is dominated by an overestimation of the CSP volume.

Prospective motion correction on diffusion weighted imaging: improving data quality with four radio frequency and gradient pulses updates.

Danilo Maziero1, Michael Herbst2, and Thomas Ernst1

1School of Biomedical Engineering, UNSW Sydney, Sydney, Australia, 2Medical Biophysics, University of Toronto, Toronto, ON, Canada
Prospective Motion Correction (PMC) using fast camera-based tracking systems can dramatically increase DWI data quality and may have an important application in populations where movement is hard to prevent. Here we present images acquired with and without intra-sequence PMC even in cases of small motion, thereby making high-resolution brain angiography more reliable.

We propose to insert Segmented FatNavs into a time-of-flight sequence, and use it as a multi-purpose module. It allows fat suppression, magnetization-transfer suppression of the tissue signal, and retrospective motion correction. Image quality was always enhanced after correction, even in cases of small motion, thereby making high-resolution brain angiography more reliable.

The diagnostic accuracy of Positron-Emission-Tomography/Magnetic Resonance (PET/MR) is often reduced in regions affected by respiratory and cardiac motion. These motion-induced artifacts can be corrected by an MR-derived motion model (MM). Here, we improved the previously presented PET/MR motion correction system by two new sampling trajectories for the MR motion imaging and extend it by the usage of an additional Compressed Sensing reconstruction (BART), an optical-flow based registration (LAP) and the incorporation of motion correction into a listmode-based PET reconstruction (CASToR) which are all integrated into the Gadgetron-based reconstruction pipeline for a clinical feasible setup. In-vivo patient data substantiated the improvements.

Physiological motion remains a major challenge for cardiac PET-MR. Here we propose a framework for non-rigid respiratory motion-corrected simultaneous Coronary MR Angiography (CMRA) and cardiac PET. Motion estimated from low-resolution MR image navigators and from CMRA data itself is used for correcting CMRA and PET datasets to the same respiratory position. The proposed CMRA approach was validated in ten healthy subjects. Results from the PET-CMRA framework on three patients show that motion-corrected PET images have improved sharpness compared to uncorrected reconstructions, whereas motion-corrected CMRA images have improved coronary vessel length and sharpness compared to uncorrected and translational-corrected images.

Subject motion limits the potential of high resolution Time of Flight (ToF) angiography at 7T, even small scale, involuntary movements can degrade the image quality. In this study, prospective motion correction was able to overcome the biological resolution limit in a healthy subject population (quality assessment with quantitative and qualitative metrics), and was used to acquire the highest in-vivo ToF data set to date with an isotropic voxel size of 0.15mm³.

Prospective motion correction using external hardware can be compromised by poor marker attachment. In this work we introduce a new attachment site on the mastoid process of the subject. To achieve this, an active wireless marker is implemented that takes advantage of the versatility of an existing method (VectOrient). The effects of the device on the scanner’s operation and visa versa are evaluated. The small 14x16mm² device shows good MRI compatibility. Any degradation in signal quality is localised and could be further reduced. The link quality is sufficient to stream patient motion parameters, quantifying patient pulse during MEMPRAGE and EPI pulse sequences.
Respiratory Phase-Matched MR-based Attenuation Correction (MRAC) for Four-Dimensional (4D) PET in PET/MRI: A Feasibility Study

Jaewon Yang, Florian Wiesinger, Anne Menini, Jing Liu, Thomas A. Hope, Youngho Seo, and Peder E. Z. Larson

PET/MRI is capable of simultaneous respiratory motion-resolved four-dimensional (4D) PET/4D MRI data acquisitions. Therefore, it is important to develop a clinically applicable method for respiratory phase-matched MR-based attenuation correction (MRAC) for accurate 4D PET quantification. This study proposed 4D MRAC protocols modifying the current MRAC protocol and evaluated their performance using a patient with liver metastases. For qualitative analysis, 4D MRAC improved phase-mismatch at the lung/liver interface substantially. For quantitative analysis, 4D MRAC improved PET quantification by 10-30% increase of PET-avid tumor uptake values, compared to static MRAC, specifically for the tumors located at the lung/liver interface.

Analysis of abdominal movement with Phase Optical Flow: Application to Diffusion imaging.

Stephan Hahn, Maxime Gérard, Damien Dasnoy-Sumell, Julie Absil, Olivier Debeir, and Thierry Metens

We present a new method, the Phase Optical Flow, which provides an automatic determination of abdominal regional movements along the cardiac cycle and allows a real time determination of the optimal cardiac trigger time to be used in quantitative liver DWI. A phase based motion amplification was applied to real-time BTFE images acquired at 20 images/s. Then optical flow was used to derive the velocity vector field. The optimal cardiac time window was defined as the 100ms-period with minimal absolute vertical velocity. Validation was provided by liver DWI obtained at several cardiac trigger times.

In vivo imaging of mean cell size and density of human breast tumors

Hua Li, Lori R. Arlinghaus, A. Bapsi Chakravarthy, Vandana G. Abramson, John C. Gore, and Junzhong Xu

We report a new MRI method termed IMPULSED (Imaging Microstructural Parameters Using Limited Spectrally Edited Diffusion) to quantitatively characterize mean cell size and density in solid tumors simultaneously and the first application of this method in breast cancer patients.

Intravoxel incoherent motion MR imaging for staging liver fibrosis and monitoring anti-fibrotic response to losartan: an experimental study in rat model

Caiyuan Zhang, Yong Zhang, and Dengbin Wang

To evaluate the feasibility of intravoxel incoherent motion (IVIM) MR imaging to stage liver fibrosis and its capability for monitoring anti-fibrotic response to treatment, we performed IVIM MR imaging for rats model induced by carbon tetrachloride and for rats treated with losartan. Our studies demonstrated that D* is helpful to stage early and moderate fibrosis, and f is beneficial to discriminate advanced liver fibrosis and cirrhosis. In losartan treated rats, D* and f showed statistical significance compared with CCl4 alone. We concluded that perfusion parameters derived from IVIM have potential to monitor fibrosis progression and evaluate anti-fibrosis response to treatment.

Diffusion-weighted MRI and coherent flow in the kidney

Andreas Max Weng, Fabian Hilbert, Henning Neubauer, Simon Veldhoen, Thorsten Alexander Bley, and Herbert Köstler

The IVIM model and typical DWI-evaluations assume flow in tissue to be incoherent. However, there is evidence that in some tissues flow might be coherent and thus, the DWI-signal might be influenced by the applied first gradient moment m1. A gradient scheme was implemented that allows applying different m1 for a constant b-value. Moreover, the IVIM model was extended to also include coherent flow in the modeling process of DWI data. It was found that flow in the human kidney is, at least in part, coherent and that the proposed model is able to fit that data very robustly.

An assessment of Intravoxel Incoherent Motion (IVIM) imaging in Detection of Acute Kidney Injury in Rodents

Keisuke Ishimatsu, Shannong Zhang, Koji Saijyama, Ming Chang Hu, Orson W Moe, and Masaya Takahashi
**Plasma 6**

**Diffusion-Weighted MRI Identifies Viable Tissue in Wilms Tumour: Application for Subtype Analysis and Response to Chemotherapy**

Harriet Rogers¹, Patrick Hales¹, Kathy Pritchard-Jones¹, and Christopher Clark¹

¹Developmental Imaging and Biophysics, Institute of Child Health, University College London, London, United Kingdom, ²Developmental Biology and Cancer, Institute of Child Health, University College London, London, United Kingdom

In Wilms Tumour (WT) Blastemal subtype has the worst prognosis. Diffusion MRI (DWI) can distinguish some histological subtypes. Gadolinium-contrast-injected T₁ MRI (T₁Gd) identifies necrotic tissue. Gadolinium is contra-indicated in renal failure. 27 patients received DWI, 20/27 received T₁Gd. DWI was fitted with Intravoxel Incoherent Motion providing Dmaps. Viable and necrotic regions identified on T₁ were transferred to corresponding Dmaps. ROC analysis determined a D threshold separating necrotic and viable tissue. ANOVAs showed viable regions separated Blastemal from other subtypes, whole lesions could not. DWI separates necrotic and viable tissue in WT potentially identifying subtypes, assessing chemotherapy, guiding biopsies and surgery.

**Plasma 7**

**Validation of VERDICT MRI using fresh and fixed prostate specimens with aligned histological slices**

Colleen Bailey², Roger M Bourne³, Bernard Siow³, Edward W Johnston³, Hayley Pye³, Susan Heavey³, Thomy Mertzanidou¹, Hayley Whitaker⁴, Alexander Freeman⁴, Dominic Patel⁴, Greg Shaw⁴, Ashwin Sridhar⁴, Shonit Punwani⁴, David J Hawkes⁴, Daniel C Alexander⁵, and Eleftheria Panagiota³

¹Centre for Medical Image Computing, University College London, London, United Kingdom, ²Discipline of Medical Radiation Sciences, University of Sydney, Sydney, Australia, ³Centre for Advanced Biomedical Imaging, University College London, London, United Kingdom, ⁴Imaging, Francis Crick Institute, London, United Kingdom, ⁵Centre for Medical Imaging, University College London, London, United Kingdom, ⁶Division of Surgery and Interventional Science, University College London, London, United Kingdom, ⁷Department of Urology, University College London Hospitals, London, United Kingdom, ⁸Department of Research Pathology, University College London, London, United Kingdom

This study provides the first step in validating the VERDICT diffusion model of tissue microstructure by examining the effects of fixation on tissue microstructure and comparing VERDICT parameter maps to histological features. Fresh and fixed parameter maps showed similar spatial trends: fixation decreased the extracellular volume fraction parameter and decreased the cell radius parameter slightly, consistent with water efflux. Intracellular volume fraction was lower in regions with lower cellularity, such as the peripheral zone, and directions of diffusion anisotropy corresponded with collagen and smooth muscle orientation patterns in the stroma.

**Plasma 8**

**Diffusion-weighted MRI in the evaluation of posttherapeutic residual masses in lymphoma**

Siarhei Kharuzhyk¹, Edward Zhavrid², and Nina Sachivko²

¹Radiology, N.N. Alexandrov National Cancer Center, Minsk, Belarus, ²Chemotherapy, N.N. Alexandrov National Cancer Center, Minsk, Belarus

Residual masses do often present on posttreatment imaging in lymphoma. We conducted prospective study to evaluate diagnostic capabilities of CT, MRI and diffusion-weighted residual masses in 40 lymphoma patients. MRI-DWI with visual analysis of apparent diffusion coefficient (ADC) maps was the most effective technique. Quantitative ADC analysis is a promising tool for differentiation of active and non-active residual masses in lymphoma.

**Plasma 9**

**The clinical evaluation of combining DWIBS with whole body T1w imaging for diagnosing bone marrow involvement in lymphoma patients: a comparison with PET/CT**

Menglan Sun¹, Jingjiang Cheng¹, Yun Meng¹, and Zhizheng Zhuo²

¹The First Affiliated Hospital of Zhengzhou University, 1st, Zhengzhou, People's Republic of China, ²Philips Healthcare, Beijing, People's Republic of China

This study aimed to evaluate the value of the combination of DWIBS (diffusion weighted imaging with background signal suppression) with whole body T1w imaging for diagnosing bone marrow involvement (BMI) in lymphoma patients, compared to PET/CT imaging. In the first part of this study, patients with newly diagnosed lymphoma were included and whole body DWIBS, T1w and PET/CT images were acquired for all 20 subjects. For the assessment of individual lesions, DWIBS with whole body T1w has advantages over DWIBS and has similar ability with PET/CT to detect BMI lesions.

**Plasma 10**

**Intravoxel incoherent motion diffusion-weighted imaging for discriminating the pathological response to neoadjuvant chemoradiotherapy in locally advanced rectal cancer**

Wen Lu¹, Yu xiaoping¹, and Zhang zhongping²

¹Hunan Cancer Hospital, Changsha, People's Republic of China, ²GE Healthcare China, Beijing, People's Republic of China

This study aimed to investigate the concept of intravoxel incoherent motion (IVM) for diffusion weight imaging (DWI) in the kidney. We first compared the variability of three methods for bi-exponential fitting applied to the five data sets of DWI obtained in a mouse kidney. Subsequently these three methods were compared with an arterial spin labelling (ASL) in detection of acute kidney injury (AKI) in a rat model. The IVM imaging did not detect any changes in the AKI model although the ASL clearly demonstrated the reduction of the perfusion.
In this study, we investigated the utility of IVIM-DWI in discriminating the pathological response to nCRT in locally advanced rectal cancer (LARC). We found that both the pre-nCRT and post-nCRT IVIM-DWI parametric values for LARC, together with their percentage changes, might benefit the evaluation of pathological response to nCRT, which suggest IVIM-DWI is potentially useful in discriminating pathological response for LARC patients.

The value of diffusion kurtosis imaging in assessing pathological complete response to neoadjuvant chemoradiation therapy in rectal cancer: a comparison with conventional diffusion-weighted imaging

Fei-Xiang Hui, Tong Tong, Yi-Qun Sun, Dang Wang, San-Jun Cai, Zhen Zhang, Grimm Robert, Xu Yan, Cai-xia Fu, and Wei-Jun Peng

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The aim of this study was to evaluate the performance of diffusion kurtosis imaging (DKI) in predicting pathological complete response (pCR) of locally advanced rectal cancer (LARC) to neoadjuvant chemoradiation therapy (CRT) before and at an early stage of the treatment, and in comparison to conventional diffusion-weighted imaging (DWI). Results showed that DKI outperformed conventional DWI in accurately differentiating between pCR and non-pCR patients who received neoadjuvant chemoradiation therapy both before and at an early stage of treatment.

The application of whole lesion IVIM analysis using iZOOM DWI in the diagnosis of thyroid tumor

Yunlong Yue, Lili Zuo, Kaining Shi, Lee Jiang, Jinsong Guo, and Yanfang Jin

1Department of MR, Beijing Shijitan hospital of capital medical university, Beijing, People's Republic of China, 2Philips Healthcare (China), Beijing, People's Republic of China, 3Philips Healthcare (China), Suzhou, People's Republic of China

To explore the ability of IVIM parameters derived from iZOOM DWI in differentiating malignant thyroid nodules from benign ones. 40 patients with 45 pathologically proven thyroid nodules were involved. iZOOM DWI with 2D RF was employed to decrease the distortion and carotid coil was used to increase the SNR. 3D ROI was drawn manually to cover the whole lesion. D and f values were significantly lower in malignant nodules than in benign nodules. According to ROC curve analysis IVIM almost reached the upper limit of the accuracy based on US.

Diffusion Spectrum Imaging Tractography of the Human Tongue

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The human tongue is known to have a complex architecture of muscles. To fully understand how the muscle fibers are connected and how their relative position could affect the tongue functionality, diffusion weighted imaging is needed. Diffusion Spectrum Imaging (DSI) is able to characterize the fiber structure on a sub-voxel level including the fiber crossing or branching. As DSI sequences are usually time-consuming, in-vivo studies using DSI can be challenging. In this study, we present for the first time DSI of the post-mortem human tongue. The associated tractography delineating the tongue muscle fibers. DSI has the ability to identify fiber crossings within the human tongue.

Acquisition at maximum blood velocity overcomes the problem of the ill-posedness of the IVIM model: a demonstration with renal diffusion MRI

Basitien Milani, Jean-Baptiste Ledoux, and Menno Pruijm

1Nephrology, CHUV, Lausanne, Switzerland, 2Radiology, CHUV, 3Nephrology, CHUV

We explain why diffusion MRI should always be acquired when blood has maximum velocity in the organ of interest. We first give some theoretical arguments to support this hypothesis. We then demonstrate it with numerical experiments and with in-vivo experiments.

Comparison of in-vivo Lung Morphometry Models from 3D Multiple b-value 3He Diffusion-Weighted MRI

Ho-Fung Chan, Juan Parra-Robles, Guilhem J Collier, and Jim M Wild

1Academic Unit of Radiology, University of Sheffield, Sheffield, United Kingdom, 2Department of Bioengineering, Universidad Carlos III de Madrid, Madrid, Spain

The cylinder (CM) and stretched exponential (SEM) models have been proposed as a means of estimating lung alveolar microstructural length scales (Lm for CM and Lm for SEM) from multiple b-value hyperpolarised gas DW-MRI. This work compares Lm and Lm in healthy normals, idiopathic pulmonary fibrosis, and COPD patients. A correlation with a non-linear trend was observed between the Lm and Lm parameters. This suggests that the two models have different operational ranges of length scale estimation accuracy due to inherent differences in their geometrical and mathematical assumptions.
Resolution Enhanced accelerated Four Dimensional Echo Planar Spectroscopic Imaging: Application in Prostate Cancer

Zohaib Iqbal1, Brian L. Burna1, Rajakumar Nagarajan1, Robert E. Reiter1, Steven S. Raman1, and M. Albert Thomas1
1Radiological Sciences, University of California - Los Angeles, Los Angeles, CA, United States, 2Urology, University of California - Los Angeles, Los Angeles, CA, United States

Prostate cancer (PCa) remains the most prevalent form of cancer in men. For diagnosis, Prostate-Specific Antigen (PSA) levels are most commonly used as a screening tool. Chemical shift imaging (CSI) methods can provide information on the biochemical concentrations of metabolites in different regions of the prostate. Here, we demonstrate a novel technique capable of improving the spatial and spectral resolution of the accelerated echo-planar J-resolved spectroscopic imaging (EP-JRESI) method, which obtains 2 spatial and 2 spectral dimensions in a single scan. This resolution enhanced EP-JRESI (RE-JRESI) method is evaluated in PCa patients and compared to the EP-JRESI results.

Initial results of combined 1H and 31P spectroscopic imaging of the prostate at 7 Tesla

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1Radiology and Nuclear Medicine, Radboud University Medical Centre Nijmegen, Nijmegen, Netherlands

Proton MR spectroscopy has proven to be a valuable tool in the evaluation and detection of prostate cancer by assessing metabolite ratios incorporating choline and citrate signals. The choline peak in the proton spectrum actually consists of several different peaks of choline containing compounds[2], of which some can be distinguished using 7 Tesla 31P spectroscopic imaging. In this work we present our first patient results of a method that combines 31P and 1H within one measurement using a 31P Tx/Rx and 1H Rx endorectal coil and we show its feasibility for correlating 31P and 1H metabolite ratios.

Reduced GABA levels correlate with cognitive impairment in relapsing-remitting multiple sclerosis

Shandong Medical Imaging Research Institute, Shandong University, Jinan, Shandong, People’s Republic of China, 2Philips Healthcare, Shanghai, China, People’s Republic of China

To investigate whether cognitive impairment in relapsing-remitting multiple sclerosis (RRMS) is associated with alterations in brain gamma-aminobutyric acid (GABA) levels, 31 RMRS patients and 26 healthy controls underwent 31P MRS and neuropsychologic assessment. GABA levels were quantified in the posterior cingulate cortex (PCC), the medial prefrontal cortex (mPFC) and left hippocampus (LHC). Patients showed reduced GABA+ in PCC and LHC, and reduced GABA+ levels correlated with cognitive function. This study demonstrates that abnormalities of the GABAergic system may be an important neurochemical mechanism of cognitive impairment in RRMS.

Patch-based super-resolution of MRSI data in multiple sclerosis patients at 7 T

Saurabh Jain1, Gilbert Hange1, Diana Sima1,2, Wolfgang Bogner3,4, Siegfried Trattnig1, Sabine Van Huffel2, Frederik Maes5,6, and Dirk Smeets1,2
1icometrix, R&D, Leuven, Belgium, 2High Field MR Centre, Medical University of Vienna, Vienna, Austria, 3Department of Electrical Engineering-ESAT, STADIUS Center for Dynamical Systems, Signal Processing and Data Analytics, KU Leuven, Leuven, Belgium, 4Christian Doppler Laboratory for Clinical Molecular MR Imaging, Vienna, Austria, 5Medical IT, iMinds, Leuven, Belgium, 6Department of Electrical Engineering-ESAT, PSI Medical Image Computing, KU Leuven, Leuven, Belgium, 7Biomaging Lab, Universiteit Antwerpen, Antwerp, Belgium

The clinical application of brain MRSI is, upon several factors, limited by the comparatively low resolution that makes it difficult to resolve lesions. This work demonstrates the application of a patch-based super-resolution (PBSR) method that increases the spatial resolution of metabolite maps obtained from MRSI. The method is validated against conventional interpolation techniques in multiple sclerosis patient measurements. Our results clearly show the benefits of PBSR over other common interpolation techniques.

Cervical spinal cord and brain MRS alterations in normal appearing white matter of multiple sclerosis (MS) patients at 3T

Patrik Oliver Wyss1,2,3,4, Anke Henning1,2, Andreas Hock1,2, Andreas Lutterotti1,2, Roland Martin1,2, and Spyros Kollias1,2
1Institute for Biomedical Engineering, University and ETH Zurich, Zurich, Switzerland, 2Max Planck Institute for Biological Cybernetics, Tuebingen, Germany, 3Swiss Paraplegic Centre, Nottwil, Switzerland, 4Institute of Neuroradiology, University Hospital Zurich, Zurich, Switzerland, 5Institute of Physics, Ernst-Moritz-Arndt University Greifswald, Greifswald, Germany, 6Department of Psychiatry, Psychotherapy and Psychosomatics Hospital of Psychiatry, University of Zurich, Zurich, Switzerland, 7Neuroimmunology and Multiple Sclerosis Research, Department of Neurology, University Hospital Zurich, Zurich, Switzerland

This investigation explores alterations of both cervical spinal cord and brain metabolite levels in normal appearing tissue in patients suffering from multiple sclerosis (MS). In the brain, a 2 dimensional J-resolved spectroscopy sequence and 2D prior-knowledge fitting is used and the metabolite cycling technique is applied to the cervical spinal cord at 3T. Relapsing-remitting MS (RRMS) and secondary progressive MS (SPMS) patients are included and alterations between brain and spinal cord metabolites are addressed.

1H-NMR of carnosine combined with 31P-NMRS to better characterize skeletal muscle pH dysregulation in Duchenne muscular dystrophy

Harmen Reyngoudt1,2, Suna Turk1,2, and Pierre G. Carlier1,2
1NMR Laboratory, Institute of Myology, Paris, France, 2CEA, DRF, PBM, MIRCen, Paris, France
The finding of an alkaline \( \text{P}_i \) pool has been established with 31P-NMRS in healthy resting skeletal muscle and the dystrophic muscle of GMRD dogs and DMD patients. The pH values corresponding to this \( \text{P}_i \) pool corresponds better with extracellular pH. Intracellular pH, however, can also be measured with 1H-NMRS, using carnosine. In a group of DMD patients, we observed that pH determined with 31P-NMRS were systematically increased, whereas this was not always the case for pH based on the measurement of carnosine, revealing two groups in dystrophic muscle: (1) pH elevated with 31P and (2) pH only elevated with 1H.

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**Apparent short transverse relaxation time of inorganic phosphate in breast cancer tissue at 7 tesla.**

Wybe JM van der Kemp\(^1\), Tij A van der Velden\(^1\), Alexander M Schmitz\(^1\), Kenneth G Gihujs\(^1\), Peter R Luijten\(^1\), Dennis WJ Klompen\(^1\), and Janneke P Wijnen\(^1\)

\(^1\)Department of Radiology, UMC Utrecht, Utrecht, Netherlands

Here we show in a patient group with breast cancer an apparent shortening of the transverse relaxation time of the Pi signal at 7 tesla, as compared to healthy breast fibroglandular tissue and propose an underlying mechanism to explain this observation.

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**Acetate metabolism towards fatty acids is down-regulated in IDH1 mutant glioma as shown by 13C MRS.**

Chloé Najač\(^1\), Marina Radouš\(^1\), Pavithra Viswanath\(^1\), Myriam M Chaumeil\(^1\), and Sabrina M Ronen\(^1\)

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IDH1 is the most prevalent driver mutation in lower-grade glioma and upgraded glioblastoma and is associated with additional metabolic reprogramming. Here, we investigated fatty acid biosynthesis and the role of acetate, which was recently recognized as a major fuel in primary glioblastoma. Labeling cells harboring either wild-type or mutant IDH1 with [1,2,4\(^13\)C]-acetate, we found a decrease in flux towards fatty acids in mutant IDH1 cells although the total fatty acid pools remained unchanged. Associated with cell biological assays, these results point to alternate sources for maintenance of fatty acid levels in IDH1 mutant cells.

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**Automatic tissue-type classification of 1H-MRSI spectra in patients with glioblastoma.**

Nuno Pedrosa de Barros\(^1\), Raphael Meier\(^2\), Martin Pletscher\(^3\), Urspter Knecht\(^3\), Mauricio Reyes\(^1\), Roland Wiest\(^1\), and Johannes Slotboom\(^1\)

\(^1\)SCA / Neuroradiology, University Hospital Bern (Inselspital), Bern, Switzerland.

Clinical-routine MRSI-data analysis is commonly performed through the visual inspection of multiple metabolite and metabolite-ratio maps, and aims at translating the different spectroscopic patterns into known tissue-types, such as, necrosis, solid tumour, tumour-infiltration, normal-brain-tissue, etc. Such translation/segmentation requires solid expertise in MR-spectroscopy, which most clinicians do not have. Bad-quality-data, as well as frequency-dependant-selection-profiles further complicate proper interpretation of MRSI-data. Therefore, to facilitate the clinical-use of MRSI, we present an automatic MRSI-tissue-type segmentation algorithm, that includes automatic-quality-filtering and selection-profile-correction. The method was tested in glioblastoma and the tissue-types were compared against an MRI-based tumour-segmentation-method.

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**High and Ultra-High Field Proton MR Spectroscopy in Early Amyotrophic Lateral Sclerosis.**

Ian Cheong\(^1\), Malgorzata Marjanska\(^1\), Dinesh Deelchand\(^1\), Lynn Eberly\(^1\), David Walk\(^1\), and Gulin Oz\(^1\)

\(^1\)University of Minnesota Twin Cities, Minneapolis, MN, United States

Amyotrophic lateral sclerosis (ALS) is a devastating disease of motor neurons with unknown etiology. Evidence suggests that the brain undergoes degenerative changes in ALS, particularly within areas of the descending motor pathway. Identifying robust and non-invasive biomarkers that are sensitive to neurodegeneration in ALS is essential for improving clinical trial design and assessment of treatment effectiveness. This study evaluated 1H-MRS-measured metabolite levels as biomarkers of disease severity. Ultra-high field (7 tesla) 1H-MRS revealed metabolic abnormalities in the motor cortex and brainstem of humans with ALS that are dependent on disease stage.

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**Detection of in vivo biomarkers in fungal brain infection models and potential determination of cell viability.**

Liesbeth Vanheems\(^1\), Amy Hillen\(^1\), Jennifer Poelmans\(^1\), Katrien Lagrou\(^1\), Greetje Vande Velde\(^1\), and Uwe Himmelreich\(^1\)

\(^1\)Laboratory of Clinical Bacteriology and Mycology, University of Leuven, Leuven, Belgium

Animal models of cerebral infection by the pathogenic fungi Cryptococcus neoformans and C. gattii were developed and assessed longitudinally by using anatomical and diffusion MRI as well as MR spectroscopy. MR spectroscopy identified in vivo biomarkers for potential etiological diagnosis and more importantly for quantification of the fungal load in living animals. Our results have great potential to assist in the differential diagnosis of brain lesions in patients, whereby MR spectroscopy is a safer, non-invasive and rapid method in comparison to traditional invasive diagnostic methods such as CSF sampling or biopsies.

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**Metabolic variability in a brief status epilepticus model.**

Julie W Pan\(^1\), Yijen Wu\(^1\), Patrice Pearce\(^3\), Nihal de Lanerolle\(^4\), and Kevin Kelly\(^5\)

\(^1\)MRRC, University of Pittsburgh, Pittsburgh, PA, United States.

Our results have great potential to assist in the differential diagnosis of brain lesions in patients, whereby MR spectroscopy is a safer, non-invasive and rapid method in comparison to traditional invasive diagnostic methods such as CSF sampling or biopsies.
Plasma 28  

Polyunsaturated fatty acid (PUFA) is associated with tumour grading – An ex vivo study on whole breast tumours using multiple quantum coherence (MQC) MRS

Sai Man Cheung1, Ehab Hussain2,3, Yazan Masannat1,4, Klaus Wahle1,4, Steven D Heys1,4, and Jiabao He1

1Aberdeen Biomedical Imaging Centre, University of Aberdeen, Aberdeen, United Kingdom, 2Pathology Department, Aberdeen Royal Infirmary, Aberdeen, United Kingdom, 3School of Medicine, University of Aberdeen, Aberdeen, United Kingdom, 4Breast Unit, Aberdeen Royal Infirmary, Aberdeen, United Kingdom

Eicosanoids are derivatives of three different PUFA, vital in membrane formation and anti-inflammatory control. The presence of eicosanoids in adipose tissue and fibroblasts governs the release of signalling agents in breast, stimulating the invasion of breast cancer cells. Lipid composition has emerged as a potential predictor of breast cancer. However, current research focuses on the tumour initiation, while the understanding of lipid function in tumour progression remains sparse. We therefore hypothesise that there is a difference in PUFA concentration between grade II and III breast cancer. We applied MQC MRS for accurate PUFA measurement on freshly excised whole breast tumours.

Plasma 29  

In-Vivo Regional detection of Gly in Human Brain: Implications in Glioma Patients at 3T

Vivek Tiwari1, Zongxu An1, Sandeep Kumar Ganji1, and Changho Choi1

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Glycine, an inhibitory-neurotransmitter and a co-agonist of N-Methyl-D-aspartate, has been implicated in rapid cancer cell-proliferation and is elevated in high-grade gliomas than low-grade. Gly concentrations range from 0.5-1.0 M in normal brain and exhibits regional-variation. Given such a low in-vivo concentration of Gly, potential overlap from mI and regional-variation, here we have developed a novel Gly-optimized single-voxel-localized triple-refocusing scheme for precise co-detection of Gly and mI in Gray-matter (GM)-rich Medial-Occipital (MO) and White-matter (WM) rich Left-Parietal (LP) healthy-brain region, and further extended to measure glycine level in glioma patients.

Plasma 30  

Differential diagnosis of Hepatic metabolites between non-alcoholic steatohepatitis and simple steatosis in humans and a murine model using a 1H MR spectroscopy study with long TE

Tae-Hoon Kim1, Hong Young Jun1, Chang-Won Jeong1, Jong-Hyun Ryu1, Kou Gyeom Kim1, and Kwon-Ha Yoon2

1Radiology, Imaging Science Research Center, Iksan, Korea, Republic of, 2Radiology, Wonkwang University School of Medicine, Iksan, Korea, Republic of

Liver biopsy is the gold standard for diagnosing non-alcoholic fatty liver disease (NAFLD) but with practical constraints. MR spectroscopy (MRS) allows in vivo assessment of hepatocellular metabolism and has shown potential for biochemical differentiation in diffuse liver disease. Recent 13C-MRS demonstrated that alanine and lactate levels in inflammatory liver injury were increased compared to those in normal liver, and these changes were positively correlated with liver enzyme levels. However, the clinical use of 13C-MRS technique is limited because it necessitates 13C-resonance specific hardwares and softwares for data acquisition. This study used long TE 1H-MRS to monitor changes of hepatocellular metabolites in NAFLD.

Electronic Power Pitch Poster

Poster: Breakthrough Methods & Applications in Cancer Imaging

Exhibition Hall  Thursday 9:15 - 10:15

Plasma 1  

High resolution imaging of the optic chiasm at 7T MRI improves lesion detection and tumour delineation compared to 3T

Guido van Haren1, Lorna Grech-Fonk1, Marco Versteegen1, Wouter Teeuwisse1, Teresa Ferreira1, Irene Notting1, Wouter van Furth1, and Jan-Willem Beenakker1,2,3

1Radiology, LUMC, Leiden, Netherlands, 2Radiology, CJ Gorter center for high field MRI, LUMC, Leiden, Netherlands, 3Ophthalmology, LUMC, Leiden, Netherlands

The limited resolution of 3Tesla MRI often leads to missed lesions or ambiguities in the tumour environment for patients with a pituitary macroadenoma. In this study we developed a robust high-resolution 7Tesla MRI-protocol of the optic-chiasmatic system and evaluated its clinical value. The 7T MR-images reveal tiny lesions in the optic nerve or chiasm which are not visible at 3T. These lesions could explain the vision loss for 3 of the 7 evaluated patients and gave the physician new treatment possibilities. Overall, this study shows the great clinical opportunities of 7Tesla MRI for patients with pituitary macro-adenoma or other neuro-ophtalmic conditions.

Plasma 2  

Accelerated 3D bSSFP Imaging for Treatment Planning on an MRI-Guided Radiotherapy System

Yu Gao1, Ziuw Zhou1, Fei Han1, Percy Lee1,3, Daniel Low1,3, Peng Hu1,3, and Yingli Yang1,3

1Advanced Imaging Research Center, UT Southwestern Medical Center, Dallas, TX, United States, 2Radiology, Imaging Science Research Center, Iksan, Korea, Republic of, 3Radiology, Wonkwang University School of Medicine, Iksan, Korea, Republic of
Multimodal and multi-scale measurement of metabolism in vivo in a breast cancer model

Benjamin L Cox1,2, Joseph M Szulczewski1,2, David R Inman1, Erin B Adamson2, Kai D Ludwig2, Justin J Jeffery2, Stephen A Graves1, Alison B Roth1, David B Mummy3, Patricia J Keely2, Kevin W Eliceiri2, and Sean B Fain1,7

1Medical Physics, University of Wisconsin - Madison, Madison, WI, United States, 2Medical Engineering, Morgridge Institute for Research, Madison, WI, United States, 3Laboratory for Optical and Computational Instrumentation (LOCI), University of Wisconsin - Madison, Madison, WI, United States, 4Cell and Regenerative Biology, University of Wisconsin - Madison, Madison, WI, United States, 5UW Carbone Cancer Center, Madison, WI, United States, 6Biomedical Engineering, University of Wisconsin - Madison, Madison, WI, United States, 7Radiology, University of Wisconsin - Madison, Madison, WI, United States

The purpose of this work is to introduce a compressed sensing and parallel imaging combined technique to reduce the acquisition time for planning MR. We implemented a variable-density Poisson-Disk under-sampled acquisition along with L1-ESPIRIT reconstruction technique on an MRI-guided radiotherapy system. Phantom study showed that our technique had superior image quality over the conventional GRAPPA approach. Patient and volunteer study demonstrated that comparable images can be acquired with half of the original time. In addition, the proposed technique was able to achieve high resolution imaging where the GRAPPA approach failed due to high noise level.

Feasibility of magnetic resonance colonography for an immune check-point inhibitor in orthotopic colorectal rechallenge tumor models

Jinil Kim1, Yoon Seok Choi1, Dong-Cheol Woo1, Chu-Woong Woo1, Sang Tae Kim1, Jae Im Kwon2, and Kyung Won Kim3

1Asan Institute for Life Sciences, ASAN Medical Center, Seoul, Korea, Republic of, 2Medical research institute, Gangneung Asan Hospital, Gangneung, Korea, Republic of, 3Department of Radiology, ASAN Medical Center, Seoul, Korea, Republic of

In the immunotherapy research field, establishing appropriate preclinical model is very important to evaluate the complex immune reaction. Orthotopic tumor model is more physiologic than ectopic tumor model, however its use may be limited due to difficulty in evaluating deep-seated tumors, especially in the colorectum having a complex anatomy. MR colonography (MRC) is a new technique in preclinical trials, which uses Fluorinert, a negative contrast agent, to fill the colorectum. Our study demonstrated that MRC is quite feasible to evaluate colorectal tumors and metastatic foci in orthotopic colorectal tumor model, which can be useful in immunotherapy drug development.

Dynamic Glucose Enhanced MRI - A prospective study in healthy volunteers and glioblastoma patients

Daniel Paech1, Patrick Schuenke2, Christina Koehler1, Johannes Windschuh1, Sibu Mundiyanapurath1, Sebastian Bickelhaupt1, Philipp Bäumer1, David Bonekamp1, Martin Bendszus1, Wolfgang Wick1, Peter Bacher2, Mark E. Ladd3, Heinz-Peter Schlemmer2, Moritz Zaiss1, and Alexander Radbruch1

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Glucose is the main energy source of cancer cells to proliferate and survive. Recently, promising results to assess changes in cellular metabolism using natural unlabeled D-glucose as biodegradable MRI contrast agent, have been reported employing Chemical Exchange Saturation Transfer (CEST) and Chemical Exchange sensitive Spin-Lock (CESL) imaging. In this work, the CESL-based dynamic glucose enhanced (DGE) contrast was investigated in healthy volunteers and a homogenous cohort of newly diagnosed untreated glioblastoma patients at 7 Tesla. DGE MRI allowed for sensitive visualization of physiological glucose uptake in the healthy human brain and pathophysiologically increased glucose enhancement of brain tumors.

3D printed Breast DCE-MRI phantom to mimic structure and pharmacokinetics

Nithin N Vajuvalli1, Cheethan Kumar M2, Amaresha Shridhar Konar1,2, Shivaprasad Ashok Chikop1, Darshan Shivaramu Keelara1, Ashwini Kummar1, Ramesh Venkatesan3, and Sairam Geethanath1

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DCE MRI plays a critical role in routine clinical breast examination. Current work focuses on the development of Breast DCE MRI phantom using a 3D printer to mimic poor and well perfused regions. The phantom developed was controlled through user entered Ktrans values entered in a GUI which interfaced with a peristaltic pump to control flow rates. The Ktrans parameters was controlled through the 3D model geometry. Prospective MR images of the phantom were acquired on a 1.5T scanner using the TRICKS sequence; and pharmacokinetic maps based on Tofts model were computed and quantified.
DCE-MRI has become an important protocol in mpMRI analysis of prostate cancer and it has been quantified typically using pharaco-kinetic modelling and the estimated parameters are then used with other approaches (machine learning or deep learning (DL)) to characterize/discriminate tumor tissue against healthy tissue. However, it is not clear if applying DL to the DCE-MRI time series directly is beneficial for prostate cancer detection. Hence, we propose a DL based method to differentiate prostate tumor from healthy tissues at the voxel level using raw arbitrary signal DCE time-series itself. Overall, DL based tumor characterization provided similar detectability for prostate tumor interventions. Significant positive correlations between MRI-derived TIFP estimates and invasive measures of TIFP were found in all groups (e.g., for untreated group, $R^2=0.76$, $p<0.0001$). These findings validate an MRI-estimated TIFP as a noninvasive measure of TIFP in embedded cerebral tumors, and suggest that it may be a useful tool in assessing tumor response to therapy.

A preclinical MRI study investigating the impact of the local microenvironment on the progression of diffuse intrinsic pontine glioma in patient-derived xenografts

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Diffuse intrinsic pontine glioma (DIPG) is a devastating childhood brain tumour with very poor outcome. The local brain microenvironment appears to play an important role in the tumourigenesis of DIPG, and is currently underinvestigated. Infratentorial and hemispheric tumour growth patterns of orthotopic DIPG xenografts were assessed longitudinally by anatomical MRI, and confirmed by immunohistochemical analysis. ADC, $T_1$ and $T_2$ were higher in infratentorial tumours than hemispheric tumours, corresponding to a higher degree of tumour-associated oedema observed histologically.

Multi-parametric MRI Radiomics for Pre-treatment Prediction of the Progression-Free Survival in Advanced Nasopharyngeal Carcinoma

Bin Zhang1

1Guangdong General hospital, Guangzhou, People's Republic of China
To our knowledge, this is the first MRI-based radiomics study to predicting survival of tumor. The results of our study show that multiparametric MRI-based radiomics nomogram significantly improves the 7th edition of AJCC TNM staging system and clinical data in predicting individualized progression-free survival (PFS) in advanced NPC (stage III/IVb). In fact, the radiomics nomogram built in our study could integrate all prognostic biomarkers/signatures that have been published in this area to improve its predictive performance. Besides, for the first time, our radiomics heatmaps showed positive associations between radiomics signature features with overall stage, T-stage and negative associations between radiomics signature features with N-stage. Our radiomics study provides some different insights into the mechanism of hematogenous and lymphatic metastasis of NPC.

Plasma 13

MR Elastography and Perfusion MRI for the Early Assessment of Treatment Response in Soft Tissue Sarcomas
Kay Pepin1, Roger Grimm2, Soudabeh Kargar3, Sarah James1, Matthew Howe1, Karen Fritch1, Matthew Frick2, Doris Wenger3, Richard Ehman3, Nadia Laack1, Michael Herman1, and Deanna Fafutil4
1Radiation Oncology, Mayo Clinic, Rochester, MN, United States, 2Radiology, Mayo Clinic, Rochester, MN, United States, 3Mayo Graduate School, Mayo Clinic, Rochester, MN, United States, 4Pathology, Mayo Clinic, Rochester, MN, United States

Advanced imaging is a critical component in the development of patient-specific and novel treatment strategies, and the non-invasive evaluation of early response in sarcomas. Our central hypothesis is that changes in sarcoma stiffness quantified with MRE and perfusion with DCE-MRI throughout therapy can predict response. Soft tissue sarcomas are a rare malignancy arising in a wide range of anatomic locations. Anatomyspecific imaging protocols were developed to evaluate soft tissue sarcomas in 9 patients. In 3 patients, we investigated the feasibility to assess response to radiation therapy and observed a decrease in parameters related to tumor stiffness and perfusion metrics.

Plasma 14

Quantitative Imaging for Radiotherapy on an MR-Linac Scanner
Folkert Koetsveld1, Leon C ter Beek2, Petra J. van Houw1, Laurens D. van Buuren1, and Ulrike A. van der Heide1
1Radiotherapy, Netherlands Cancer Institute, Amsterdam, Netherlands, 2Radiology, Netherlands Cancer Institute, Amsterdam, Netherlands

The MR-Linac integrates a radiotherapy treatment machine. Patients undergoing radiotherapy treatment will be imaged daily on the MR-Linac. We investigated the suitability of the MR-Linac as a platform for quantitative imaging. Daily quantitative imaging can be used for imaging biomarker discovery, and give information on tumor treatment response. We did phantom studies of four quantitative MRI techniques: T2 mapping, dynamic contrast enhanced imaging, T1 mapping and diffusion weighted imaging to determine the accuracy of these techniques on the MR-Linac. We tested the repeatability of T2 mapping on a volunteer.

Plasma 15

Support vector machine for breast cancer classification using DWI histogram features: preliminary study
Igor Vidić1, Liv Egnell1, Jose R. Teruel2, Torill E. Sjøbakk3, Neil P. Jerome1, and Tone F. Bathen1
1Department of Physics, Norwegian University of Science and Technology (NTNU), Trondheim, Norway, 2Department of Radiology, University of California, La Jolla, CA, United States, 3Department of Circulation and Medical Imaging, Norwegian University of Science and Technology (NTNU), Trondheim, Norway

In this work we use the machine learning method support vector machine (SVM) to classify malignant and benign tumors, as well as ER+HER2- and ER+HER2+. As feature we use histogram properties of DWI-models (RED, ADC, IVIM) parameters as features. Our study showed that SVM classifiers using combinations of features from different models have predictive power in both analyses, also it performed better than SVM using combination of parameters obtained only from one of the models. The results are encouraging because SVM with DWI parameters can potentially hinder unnecessary biopsies.

Electronic Power Pitch Poster

Poster: Contrast Mechanisms: New Horizons
Exhibition Hall Thursday 9:15 - 10:15

Plasma 16

On the decay of SSFP configurations
Damien Nguyen1, 2, Rahel Heule1, 2, Carl Ganter1, and Oliver Bieri2
1Radiological Physics, University of Basel Hospital, Basel, Switzerland, 2Department of Biomedical Engineering, University of Basel, Basel, Switzerland

In this work, we explore the decay of negative and positive steady state configurations as a mean to assess the tissue microstructure. Steady state configurations are retrieved up to a high order from an exhaustive sampling of the frequency response profile of low-angle balanced SSFP scans. Subsequently, the decay of configurations (termed DECO) is analyzed using a single-pole matrix pencil analysis yielding positive and negative DECO images. Any asymmetry in the configuration decay is directly linked to asymmetric frequency content within a voxel and is captured in the DECO difference image.

Plasma 17

Asymmetries of the balanced SSFP profile allow to probe microstructure anisotropy at 9.4 Tesla
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The bSSFP signal profile exhibits tissue-dependent asymmetries that can be used as a novel contrast mechanism and have been hypothesized to relate to the tissue microenvironment. In this work, we investigate this effect at ultra high-field using phase-cycled bSSFP at an isotropic resolution of 1.2 mm. As in the original publication, we also observe strong asymmetries in white matter and a comparison to DTI data reveals that the largest asymmetries occur in white matter tracts oriented orthogonal to the main magnetic field.

bSSFP was shown to be sensitive to exchange and is explored as an alternative way for CEST/T_{xy} experiments (the bSSFPX method). In this abstract, an analytical solution is derived for the magnetization behavior in the bSSFPX. The solution describes the transient signal fluctuations for short saturation times. The solution is verified by comparing it to full, step-wise computation of Bloch-McConnell Equations. Overall, this solution is in good agreement with Bloch-McConnell Equations and follows the transient signal oscillations well. Work is in progress to use this solution to quantify exchange rates experimentally.

We measured spin-lock relaxation rates as a function of locking field to quantify tissue pH and the concentration of an exogenous X-ray contrast agent, iohexol, based on chemical exchange effects. Results show that spin-lock imaging can be used to detect exchange-based agents and the effects of tissue acidification.

MRI measurements of cerebrovascular function and structure are important for understanding neurodegenerative disease mechanisms. In this study, a novel contrast-enhanced multi-flip angle multi-echo (MFAME) MRI technique capable of simultaneously quantifying vessel permeability surface area product to water (PS_{SA}), blood water population fraction (p_b), and contrast agent r_2* is presented, and applied to a transgenic rat model of Alzheimer’s disease (TgF344-AD). Transgenic rats exhibit higher p_b and lower PS_{SA} in the hippocampus compared to wild-types, suggesting MFAME MRI may be sensitive to regional pathologic microvascular alterations in this model.

This study explores and demonstrates the opportunities opened by ultrahigh fields for in vivo CEST-weighted imaging. CEST-weighted fast spin-echo imaging was performed on two neurological models: hypoxic ischemic and glioblastoma. A remarkably strong CEST contrast (≈15%) was observed for the tumors at 3.32 ppm originating mainly from an APT increase and a strong decrease in NOE and MT. Ischemic lesions were still more robustly detected with standard T_{2} -weighted images than with CEST. Potential explanations and dependence with high magnetic field are discussed.

Whether Magnetization Transfer could affect Multiexponential T_{2} (MET) Relaxometry remains poorly explored. Here, the effects of irradiation at different offset frequencies on the MET components were evaluated as novel contrast mechanisms for white matter in the rat spinal cord at 16.4T. MET coefficients were found to shift with off-resonance saturation, showing unique tract-specific signatures across the irradiation frequency. Offset-saturation-induced (osi-) MET Relaxometry maps show strong contrasts between microstructurally-distinct rat spinal cord tracts. The potential of exploiting the osi-MET shift phenomenon to increase white matter contrast is discussed.

Magneto-Caloric Materials as Tunable and Switchable Labels for MRI
Plasma 24

Detecting regional changes in brain tissue quantitative T1 values due to hydration status

We present the case for the use of magneto-caloric materials as tunable and switchable labels for MRI. Sharp magnetic phase transitions these materials have at typical physiological temperatures and in the presence of the large DC magnetic field values associated with MRI machines make them uniquely suitable for the development of novel MRI contrast agents. We present present the MR image contrast changes due to the temperature tunable magnetic state of the material in the MRI compatible magnetic field range and physiologically relevant temperature range.

1000 Plasma 24

The T1-Dispersion Curve as a Biomarker of Colorectal Cancer

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A graph of $T_1$ versus applied magnetic field, obtained via Fast Field-Cycling (FFC) NMR relaxometry, can be used as a diagnostic tool thanks to the information it provides about molecular dynamics. In this work, FFC NMR relaxometry, extended to magnetic fields below 17 μT, was used to investigate new biomarkers of colorectal cancer. The acquired results indicate that there were significant differences in the molecular motions with correlation times 0.1-10 ms and 0.5-1.4 μs between the healthy and cancer tissues examined, showing great potential for diagnosis, staging and monitoring response to treatment.

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Detecting regional changes in brain tissue quantitative T1 values due to hydration status

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Volumetric/morphometric changes in brain structures are often investigated as markers for disease or drug-induced effects. Brain tissue has been shown to shrink during mild dehydration which is not typically controlled for in MRI studies thus potentially confounding the results. Quantitative T1 is expected to change in response to changes in water content of tissue. Here, we show for the first time, that T1 maps, shifts in volumetric/morphometric studies and may aid in the interpretation of results.

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In vivo whole-blood $\text{T}_2$ versus $\text{HbO}_2$ calibration by modulating blood oxygenation level in the femoral vein through intermittent cuff occlusion

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The relationship between whole-blood $T_2$ and blood hemoglobin oxygen saturation ($\text{HbO}_2$) can be modeled as $\text{T}_2=\frac{1}{\text{HbO}_2(1-\text{HbO}_2)}$, where $K$ and $T_2$ are determined empirically in vitro. The feasibility of estimating $K$ and $T_2$ in vivo is investigated with $T_2$-prepared bSSFP at 1.5T in the superficial femoral vein (SFV) with intermittent cuff occlusion. In this manner a range of $\text{HbO}_2$ were achieved allowing quantification of venous oxygen saturation via MR susceptibility, a method that had been validated rigorously against blood gas analysis. Initial result ($K=19.6\text{Hz}, T_2=185\text{ms}$) is lower than the literature value (24.6Hz, 254ms) but not unexpected because transient bSSFP signal is acquired while disturbing the $T_2$-prepared magnetization.

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Visualizing local mechanical properties of agar phantoms and meningioma patients using magnetic resonance rheology

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Magnetic resonance rheology is a novel method to create an imaging contrast based on the mechanical properties of brain tissue. It is based on a short fall of the head that creates a broadband excitation of the tissue. The resulting deflections of the tissue elements are depicted using motion sensitive phase imaging. This contribution presents measurements on agar phantoms as well as four meningioma patients to show the feasibility of the method to depict local alterations of the mechanical properties of the investigated material.

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Early Cancer Detection Using Paramagnetic Liposome by a Novel Contrast Mechanism with Active-feedback Magnetic Resonance Imaging

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The relationship between whole-blood $T_2$ and $\text{HbO}_2$ can be modeled as $\text{T}_2=\frac{1}{\text{HbO}_2(1-\text{HbO}_2)}$, where $K$ and $T_2$ are determined empirically in vitro. The feasibility of estimating $K$ and $T_2$ in vivo is investigated with $T_2$-prepared bSSFP at 1.5T in the superficial femoral vein (SFV) with intermittent cuff occlusion. In this manner a range of $\text{HbO}_2$ were achieved allowing quantification of venous oxygen saturation via MR susceptibility, a method that had been validated rigorously against blood gas analysis. Initial result ($K=19.6\text{Hz}, T_2=185\text{ms}$) is lower than the literature value (24.6Hz, 254ms) but not unexpected because transient bSSFP signal is acquired while disturbing the $T_2$-prepared magnetization.
The detection of early tumors requires creating the contrast between healthy and tumor tissues that share a common morphology, making it difficult to distinguish them by relaxation-based MRI technique. Here we have exploited the small magnetic differences between the healthy and tumor tissues to develop a detection technique of early tumors using theranostic nanoparticle paramagnetic (Gd) liposome along with continuous wave (CW) irradiation in the presence of the feedback magnetic field from an active-feedback electronic device for in vivo subcutaneous glioblastoma multiforme mouse models and obtained significantly superior contrast compared to the conventional MRI technique, in agreement with spin-dynamics simulations.

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**Analysis of magnetohydrodynamic effects in current injection induced magnetic flux density images at very high magnetic fields**

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Magnetic resonance imaging based electrical conductivity imaging of biological tissues could be highly challenging at magnetic fields of the order of 18.8T. We could see significant magnetohydrodynamic (MHD) effects in low viscosity materials at such fields. In this study, we investigated these effects using saline and agarose phantoms and explained the MHD mechanism using a fluid flow model coupled with electromagnetic field equations. Experimental and simulation results showed a correlation between the higher magnetic field and velocity. This relation changed from exponential to linear as the viscosity of material increased. The velocity was negligible for highly viscous materials such as agarose.

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**Quadrupolar jump-and-return sequence for sodium knee MRI at 7 tesla**

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Glycosaminoglycans (GAGs) is an important biomarker for the diseases related to the degradation of cartilage tissues. The GAG content in cartilage tissue is known to be well correlated with the sodium concentration. In addition, the collagenous extracellular matrices of cartilage tissues provide sodium ions with ordered environments. Recently, the so-called quadrupolar jump-and-return (QJR) sequence has been developed, which can selectively detect sodium ions in ordered environments. In this work, we demonstrate the feasibility of the QJR sequence for in vivo knee MRI by assessing its performance on the contrast modification to cartilage tissues and fluid.

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**Approaching free intracellular diffusion by diffusion-weighted MRS at ultra-short time scales: initial results in the rodent brain using a 1.5 T/m gradient**

Clémence Ligneul, Marco Palombo, Julien Flament, and Julien Valette

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At ultra-short time scales, intracellular metabolites are expected to experience less restriction, so that their apparent diffusion coefficient (ADC) as measured by diffusion-weighted MRS should approach the free intracellular diffusivity in a manner which depends on small microstructural features. In this work we use a unique gradient insert capable of reaching 1.5 T/m to measure metabolite ADC in the rat brain up to 665 Hz using oscillating gradients (corresponding to 0.21-ms diffusion time in the Mitra limit), in order to approach and estimate free intracellular diffusion.

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**Accurate estimation of intra-axonal diffusivity and anisotropy of NAA in humans at 7T**

Henrik Lundell, Carson Ingo, Tim Bjørn Dyrby, and Itamar Ronen

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Diffusion weighted spectroscopy offers a unique probe for tissue microstructure and recent studies demonstrate NAA diffusivity as an independent marker of axonal health. In this study we address the problem of macroscopic dispersion of fiber directions and suggest the use of high angular gradient resolution and powder averaging as an experimentally inexpensive and accurate way to solve this problem. We explore the limits of this approach in simulations and in experiments on humans at 7T.

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**Glutamate diffusion at high b-values in the rat brain in vivo under light and deep anesthesia conditions**

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Diffusion weighted spectroscopy offers a unique probe for tissue microstructure and recent studies demonstrate NAA diffusivity as an independent marker of axonal health. In this study we address the problem of macroscopic dispersion of fiber directions and suggest the use of high angular gradient resolution and powder averaging as an experimentally inexpensive and accurate way to solve this problem. We explore the limits of this approach in simulations and in experiments on humans at 7T.
Magnetic resonance techniques are developed to measure brain glutamate (Glu) concentrations but still not able to detect synaptic Glu release. In the currently study, in vivo diffusion-weighted MRS using low to very high b-values was performed on rat brain prefrontal cortex under both light and deep anesthesia conditions. Significant Glu diffusion and concentration changes were observed under different anesthesia levels in the absence of similar changes in NAA or creatine. The slower diffusion and lower concentration under deep anesthesia may reflect more Glu packed into synaptic vesicles with reduced mobility and NMR visibility.

Bias in the apparent exchange rate measurements: insight from numerical simulations
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Using double diffusion encoding it is possible to acquire microstructural and water exchange information. Here, simulations are used to study how restriction effects influence apparent exchange measurements. The simulations indicate that at the chosen experimental parameters the restriction effect can be considerable for large pores and small mixing times, \(\tau_r\). In typical exchange rate experiments using clinical MR systems with \(\tau_r > 40\) ms, the restriction effect can probably be neglected if pores are small.

Microscopic anisotropy with spectrally modulated q-space trajectory encoding
Henrik Lundell1, Markus Nilsson2, Tim Bjem Dyrbyl1,2, Geoff JM Parker1,3, Penny L Hubbard Cristinacce1, Fenglei Zhou1, Daniel Topgaard1,6, and Samo Lasic1,7
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Multi-dimensional diffusion encoding can, in contrast to conventional diffusion encoding, disambiguate between isotropic and anisotropic diffusional variance in multicompartment systems. This is done by varying the shape of the encoding tensor, i.e. going from measuring one projection of the diffusion tensors to measuring the trace of the diffusion tensors. Additional morphological features, such as the sizes of cells, are reflected in the diffusion spectrum. In this study we combine encoding tensors with varying spectral content and shape. This augmented protocol demonstrates distinctively different levels of microscopic fractional anisotropy (µFA) and time-dependent diffusion in phantoms and in white matter, cerebral cortex, and cerebellar cortex in a fixed monkey brain.

Can we detect the effect of spines, leaflets and beads on the diffusion of brain intracellular metabolites? A confrontation between high b-values and high-frequencies diffusion-weighted MRS in the mouse brain in vivo.
Marco Palmibo1, Clemence Ligneu1, Edwin Hernandez-Garzon1, and Julien Valette1
1Molecular Imaging Research Center (MIRCen), Commissariat à l’Energie Atomique, Fontenay-aux-Roses, France

Prior models used to clarify which aspects of tissue microstructure mostly affect intracellular diffusion and corresponding diffusion-weighted magnetic resonance signal have focused on relatively simple geometrical descriptions of the cellular microenvironment (spheres, randomly oriented cylinders, etc...), neglecting finer morphological details which may have an important role. Neuritis may exhibit beading; some types of neurons present high density of spines; and astrocytes and macroglial cells processes present leaflets, which may all slow the impact diffusion process. Here we use numerical simulations to interpret metabolites diffusion-weighted MRS data in the mouse brain in terms of such fine secondary structures.

Diffusion MRI of axonal degeneration in areas of fiber crossing: Histological correspondence.
Luis Concha1, Jorge Larriva-Sahd1, Gilberto Rojas-Vité1, Ramás Noguez-Imm1, Ricardo Coronado-Leija2, Alonso Ramírez-Manzanares2, and José Luis Marroquín2
1Institute of Neurobiology, Universidad Nacional Autónoma de Mexico, Queretaro, Mexico, 2Computer Science, Centro de Investigación en Matemáticas, Guanajuato, Mexico

The tensor model has been widely used to infer characteristics of white matter through diffusion MRI. Unfortunately, this model does not provide reliable information about crossing fiber regions. Several models have been proposed that seem to overcome the limitations of the tensor. However, biological interpretations of such models are limited by the lack of histological confirmation. Using an animal model of axonal degeneration, we compare histology to data derived from two approaches (CSD and multi-tensor), in an effort to provide validation of metrics that can bring substantial and clinically useful information about crossing fiber regions.

Diffusion anisotropy in breast cancer tissue corresponds to spatial patterns of collagen alignment from structure tensor analysis of histology
Colleen Bailey1, Francesco Grussu1, Bernard Slow5,3, Thomy Mertzianidou1, John H Hipwell1, Julie Owen2, Patrycja Gazinska2, Sarah E Pinder4, Daniel C Alexander1, David J Hawkes1, and Eleftheria Panagiotaki1
1Centre for Medical Image Computing, University College London, London, United Kingdom, 2Institute of Neurology, University College London, London, United Kingdom, 3Centre for Advanced Biomedical Imaging, University College London, London, United Kingdom, 4Imaging, Francis Crick Institute, London, United Kingdom, 5Breast Research Pathology, King’s College London and Guy’s Hospital, London, United Kingdom
A 3D electron microscopy segmentation pipeline for hyper-realistic diffusion simulations

Michiel Kleinjijenhuis1, Erin Johnson2, Jeroen Molink1,3, Saad Jbabdi1, and Karla Miller1

1Oxford Centre for Functional MRI of the Brain, University of Oxford, Oxford, United Kingdom, 2Sir William Dunn School of Pathology, University of Oxford, Oxford, United Kingdom, 3Department of Anatomy, Donders Institute for Brain, Cognition & Behaviour, Radboud University Medical Center, Nijmegen, Netherlands

Simulations of the diffusion signal can shed light on how the MR signal is generated from particular tissue microstructure. In our approach we use microscopy data to generate a realistic ground truth for investigating diffusion properties. We have developed a method to automatically segment large volumes of 3D electron microscopy data into individual axons for diffusion simulations. From these segmentations, we can also derive benchmark tissue microstructure characteristics such as axonal diameter, g-ratio and other compartment properties.

Rotationally invariant mapping of microstructural and orientational neuronal tissue parameters in human brain

Dmitry S Novikov1, Jelle Veraart1, Ileana O Jelescu1, and Els Fieremans1

1Radiology, NYU School of Medicine, New York, NY, United States

We develop a general framework for estimating orientational and microstructural parameters of neurites. By employing a set of rotational invariants, we analytically reveal the nontrivial topology of the parameter estimation landscape, showing that multiple branches of parameters describe the measurement almost equally well, with only one of them corresponding to the biophysical reality. A comprehensive acquisition shows that the branch choice differs for white and for gray matter. We reveal hidden degeneracies in MRI parameter estimation for neuronal tissue, provide microstructural and orientational maps in the whole brain without constraints or priors, and assess commonly used parameter constraints.

Isotropic Diffusion Weighted MRI (IDWI) – a novel, efficient clinical method for quantifying orientationally-averaged properties of tissue diffusion in tissues

Alexandru Vlad Avram1, Joelie Sarlós2, Elizabeth Hutchinson3, and Peter Basser3

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We propose a novel, efficient diffusion method, called isotropic diffusion weighted MRI (IDWI), for measuring orientationally-averaged properties of tissue water diffusion, free from modulations due to anisotropy. Using efficient diffusion gradient sampling schemes, IDWI rapidly and accurately quantifies the mean apparent diffusion coefficient (mADC) over a wide range of b-values, along with other important rotation-invariant intrinsic microstructural parameters, such as the mean t-kurtosis. The ability to efficiently and effectively remove modulations due to anisotropy in images with high-b values may improve existing diffusion MRI techniques and spur the development and clinical translation of new methods with improved biological specificity.

Diffusion MRI differentiated acute inflammation from axonal injury but missed axonal loss

Tsen-Hsuan (Abby) Lin1, Michael Wallendorf2, Peng Sun1, and Sheng-Kwei Song1,3,4

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Diffusion MRI with higher b-values and custom-designed diffusion schemes are critical to identify subtle and coexisting pathology in CNS. In the current study, we employed single-axial high-b diffusion-weighted imaging (DWI) and low-b diffusion basis spectrum imaging (DBSI) to assess mouse optic nerve crush acutely. The results suggested coexisting CNS pathology affected apparent diffusion coefficient (ADC), and low-b DBSI was able to reflect axon and myelin integrity as well as inflammatory edema and cellularity even before histological detection. DBSI-detected axon volume correlated with axonal loss negatively, suggesting cytotoxic-edema-associated axonal swelling might mask axonal loss acutely.

Three-Dimensional Multiplexed Sensitivity Encoding and Reconstruction (3D-MUSER): 3D Phase Correction for 3D Multi-shot DWI

Hing-Chiu Chang1, Edward S. Hui2, Xiaoxi Liu1, Pui-Wai Chiu1, and Nan-kuei Chen3,4

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3D interleaved DW-EPI with 2D multiplexed sensitivity encoding has been shown useful in achieving submillimeter DTI. Similar to other 3D DTI techniques, 2D phase variation is only considered in eliminating aliasing artifacts, thereby limiting feasible slab thickness. 3D phase correction is a potential strategy to significantly improve the image quality and feasible slab thickness of 3D DTI. To enable 3D phase correction, we develop a new reconstruction algorithm, and implement an EVI-based navigator echo for direct 3D phase measurement. Quantitative results show that the proposed algorithm can effectively eliminate aliasing artifacts and signal corrulations due to 3D inter-shot phase variations.
Visualizing Axonal Damage in Multiple Sclerosis Using Double Diffusion Encoding MRI in a Clinical Setting
Grant Kajun Yang1, Qiuyan Tian1, Christoph Leuzer1, Max Wintermark2, and Jennifer McNab2

Double diffusion encoding (DDE) measurements of microscopic anisotropy show promise as a method of assessing neurodegeneration. Unfortunately, DDE has yet to be demonstrated in a clinical setting due to constraints in SNR and scan time. Here, we used an optimized gradient orientation scheme to show the first DDE measurements of microscopic anisotropy in multiple sclerosis (MS) patients. Five MS patients were scanned using a DDE sequence optimized to run in five minutes. The microscopic anisotropy maps show improved visualization of axonal damage compared to fractional anisotropy (FA) and may provide additional insight into changes in tissue microstructure.

Accelerated Diffusion-Sensitized MR Imaging of the Eye and Orbit at 3.0 T and 7.0 T free of Geometric Distortions Using a Combined RARE-EPI Acquisition Technique
Katharina Paul1, Helmar Waiczies2, André Kuehne1, Till Huehnhagen1, Eva Oberacker1, Oliver Stachs1, and Thoralf Niendorf1,2,4

Diffusion-weighted imaging of the eye and orbit is an emerging MRI application to provide guidance during diagnostic assessment and treatment of ophthalmological diseases. RARE based diffusion-sensitized imaging (ms-RARE) provides images free of geometric distortions. Yet imaging speed, RF power deposition and artifacts by involuntary eye motion remain a concern. Combined acquisition techniques (CAT) merging RARE and EPI within one echo train offer the possibility to shorten acquisition times and relax specific absorption rate constraints. This study examines the applicability of RARE-EPI CAT for diffusion-sensitized imaging of the eye and orbit free of geometric distortions at 3.0 T and 7.0 T.

Characterization of White Matter Tortuosity using High-Resolution gSlider-SMS Diffusion Imaging
Choukri Mekkaoui1*, Marcel P. Jackowski2, Kawin Setsompop1, Qiuyan Fan1, Ned A. Ohlrich1, William J. Kostis1, Timothy G. Reese1, Alexandra J. Golby1, and Susie Y. Huang1

Conventional tractography excludes acute directional changes. We define these acute changes as tortuosity and use it to characterize gray-white matter boundaries, as well as quantify deformation and remodeling in pathologic states. Five healthy volunteers and a brain tumor patient were scanned using the gSlider-SMS technique. Diffusion data was processed to create 3D contiguous ribbons that characterize tortuosity. Twisting angles of the 3D ribbons were compared within and between subjects, and were visually and statistically consistent. This highly informative tractographic method could be applied to evaluate tumor infiltration and adjacent brain compression, or traumatic brain injury.

In Vivo Characterization of an Ultrashort-T2 Component in the Brain Reveals a Chemical Shift
Peder Eric Zufall Larson1, Tanguy Boucneau2, Shuyu Tang3, Misung Han4, Peng Cao5, and Roland G. Henry2

A new approach for direct measurements of myelin content is to image an sub-millisecond T2 component in the brain, likely associated with myelin membrane protons. This study characterized this ultrashort-T2 component across the whole brain using a novel relaxometry approach at ultrashort echo times (UTES). This component had an estimated T2* ~ 0.6-1.0 ms at 3T and ~0.2-0.4 ms at 7T, as well as an approximately -3.2 ppm frequency shift from water that has never been measured before in vivo. This verifies that the ultrashort-T2 component primarily arises from methylene protons, as in the myelin phospholipid membranes.

Improved Differentiation of Low- and High-Grade Gliomas by APT Contrast Fitted from Z-Spectrum
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The applicability of RARE-EPI CAT for diffusion-sensitized imaging of the eye and orbit free of geometric distortions at 3.0 T and 7.0 T.
Preoperative grading is important for treatment planning in glioma patients. Amide proton transfer (APT)-weighted imaging is helpful in grading since it reflects metabolic changes associated with mobile proteins and peptides. However, the conventional APT based on asymmetrical analysis receives contaminations from semi-solid magnetization transfer asymmetry and nuclear overhauser enhancement effects. Multicomponent Z-spectral fitting for the separated quantification of APT can help to remove those contaminations. In this study, we performed such fitting on Z-spectral data from glioma patients. We found that fitted APT provided higher power in differentiating low- and high-grade gliomas compared to the conventional APT quantification.

3T 1H PRESS (TE 68 ms) reveals elevated cerebral glucose in patients with diabetes mellitus type 2, which is associated with fasting blood glucose.

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A standard 1H PRESS sequence, with a TE of 68 ms, acquired at 3T is applied to investigate differences in cerebral glucose concentrations in type 2 diabetes mellitus (T2DM) compared with controls with normal glucose metabolism. Subjects with T2DM (n=38) display an increased cerebral glucose level compared to controls (n=38). These levels are also associated with two blood glucose measures, fasting blood glucose (FBG) and glycedated hemoglobin (Hba1c).

Towards opto-fMRS: Ultra high field MRS measurement of T2* changes due to optogenetic stimulation

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Combining optogenetics with fMRI/MRS (opto-fMRI/opto-fMRS) offers the unique potential to study the whole brain functional or neurochemical effects of stimulating specific neuronal populations within a given brain region. In this study, we investigated the BOLD functional changes and neurochemical changes resulting from optogenetic stimulation of glutamatergic or GABAergic neurons in the medial septum. Stimulation of both glutamatergic and GABAergic neurons in the medial septum resulted in prominent bold activation within the hippocampus, and in other regions. This study represents a unique imaging investigation into the functional response to stimulation of multiple distinct neuronal populations within a single brain region.

Glycine, a marker of survival in paediatric brain tumours measured with non-invasive Magnetic Resonance Spectroscopy: A five-year survival analysis.

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Brain tumours have a high mortality rate and are the most common solid tumour of childhood. MRS is a non-invasive imaging technique that measures tumour metabolites which can provide prognostic information to aid clinical management. The metabolite glycine is associated with proliferation and tumorigenesis through the one-carbon metabolic cycle. Glycine concentration has been shown to increase with tumour grade using short echo time MRS at 1.5T, however has not been assessed as a survival marker. This study investigates glycine as a marker of survival in paediatric brain tumours and assesses its added value compared to other established metabolite survival markers.

About the complementarity of gluCEST and 1H-MRS for the study of neurodegenerative diseases using animal models

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Animal models of neurodegenerative diseases are useful tools to investigate neurodegenerative diseases. However, there is often a wide variety of described models for a same pathology, each model exhibiting its own characteristics. In this work, we used two mouse models of Huntington’s disease exhibiting very different alterations. Using a protocol combining gluCEST imaging and 1H-MRS, we showed that, while gluCEST may evidence alterations in unexpected brain regions, it may also be blind to disease process in certain situations where glutamate levels are preserved. This highlights the complementarity of both methods to identify relevant biomarkers of the pathology.

A “Glycolytic Index” for quantifying abnormal metabolism in human gliomas using multi-echo amine chemical exchange saturation transfer spin- and-gradient echo echoplanar imaging (ME-aCEST-SAGE-EPI) at 3T

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Abnormal metabolism is a hallmark of cancer. The current study demonstrates use of a novel imaging technique for fast, simultaneous pH- and hypoxia-weighted images using multi-echo amine chemical exchange saturation transfer spin-and-gradient-echo echoplanar imaging (ME-acEST-SAGE-EPI). From these data, we demonstrate use of a “glycolytic index”, quantified as the ratio of relative acidity to metabolic rate of oxygen, in estimating metabolically active tumor tissue in 15 patients with gliomas. The glycolytic index showed unique heterogeneous metabolic contrast within the tumor region, and was able to easily stratify tumor from healthy tissue when compared with other imaging techniques.

We evaluated the reliability and clinical value of amide proton transfer-weighted (APTW) MR imaging at 3 Tesla in adult gliomas. Fifty-seven patients with primary gliomas were recruited and scanned. Two radiologists evaluated the location and size of the APTW hyperintensity and enhancing areas, and measured the tumor and contralateral normal-appearing white matter (CNAWM) APTW values. The correlation between relative APTW (rAPTW) values and pathologic grades was calculated. Results showed APTW analysis had good reliability. APTW images almost showed the same compared with T1-weighted contrast-enhancing (T1W+C) images. The tumor rAPTW values had a strong positive correlation with pathologic grades.

To evaluate sodium concentrations in subgroups of patients with clinically manifest migraine, 12 patients underwent a cerebral 23Na-magnetic resonance imaging examination using a dual-tuned (23Na/1H), dedicated head-coil. 23Na-sequences were reconstructed according to a T1-MP-RAGE, allowing direct cross-referencing of predetermined regions-of-interest (ROI). Significant differences in sodium concentrations could be observed for the white matter and anterior cerebrospinal fluid in patients with and without accompanying aura (p<0.05). These data suggest, that cerebral sodium concentrations may have the potential to differentiate between different subgroups of migraine.

Although conventional 1H MRI is commonly used for diagnosis and monitoring disease progression in multiple sclerosis (MS), it is not specific to pathology and cell vitality, and is limited in differentiating underlying pathology in MS lesions. In this study, using sodium (23Na) MRI, we demonstrated several subtypes of MS lesions with different sodium concentration changes, which may represent various stages of demyelination and axonal injury. Such information that is not available on conventional imaging may have value in characterize early versus chronic inactive lesions in MS.

We demonstrate the clinical feasibility and utility of a 3D Dixon TSE sequence in imaging the brachial plexus nerves in children. The employed high spatial resolution MR Neurography (MRN) technique utilizes a refocusing flip angle train to maximize nerve signal and to suppress cerebrospinal fluid signal. Additionally, a T2-preparation with motion-sensitizing gradients was employed to suppress flowing blood signal and Dixon-based chemical-shift water-fat imaging was used to suppress fat signal in the head, neck, and chest. We illustrate this MRN technique in delineating the brachial plexus nerves and associated pathological conditions in 25 pediatric patients (age range: 6 months-21 years).

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Diabetic peripheral neuropathy (DPN) is an irreversible complication that often remains undiagnosed until advanced stages. Thus, to prevent progression of DPN, early diagnosis is important emphasizing the need for more sensitive diagnostic techniques. Diagnosis is based on a neurological examination, nerve conduction studies, and quantitative sensory testing. Magnetic-resonance-neurography (MRN) enables microstructural nerve fascicle imaging of peripheral neuropathies (1–4). In a previous study on patients with severe DPN we found that diffusion-tensor-imaging (DTI) is a reproducible method in detection of DPN (5). Furthermore, DTI-MRN provided a more accurate group separation than by changes based on T2 or proton-density contrast.

Optimal quantitative mapping of Cerebral Metabolic Rate of Oxygen (CMRO2) by combining quantitative susceptibility mapping (QSM)-based method and quantitative BOLD (qBOLD)

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Current two CMRO2 mapping methods, QSM-based method and qBOLD, suffer from the issues in their own model assumptions, such as blood flow challenge and linear relationship assumption between cerebral blood volume (CBV) and flow (CBF) in QSM-based method and the high sensitivity to noise and recent one-compartment assumption in qBOLD. We combined these two models with regularization based on that vein blood volume fraction and vein oxygenation are shared, which removes the challenge and linear assumption in QSM method and alleviates the high noise sensitivity and one-compartment assumption issue in qBOLD. The proposed model provided more uniform OEF and CMRO2.

Asynchronous Local Analysis of simultaneous BOLD ASL Multislice Acquisition (ALABAMA): Toward Whole-Brain Noninvasive Estimation of Resting-State Neuronal-Vascular Coupling

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A method (ALABAMA) for regional estimation of the coupling between R2* fluctuations and log signal intensity (S0) (related to R2*-CBF coupling via a calibration factor) during the resting state is proposed. The method incorporates pseudo-continuous ASL (pCASL) labeling together with simultaneous multi-slice (SMS) and double-echo EPI acquisition for fast temporal resolution. The sequence yields robust positive ΔR2*-Δln S0 correlations in most resting-state networks, which may then be used to estimate resting-state neuronal-vascular coupling (NVC) with an additional calibration scan. However, negative correlations were found in posterior DMN and central executive network (CEN) regions, possibly reflective of altered flow-metabolism relationships.