SYMPOSIUM REPORT

Ultra High Resolution MR Imaging in the AI Era

Lecture 1

Technical Innovations for Translational Neuroscience and Clinical Applications

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Professor of Medical Neuro-Imaging
Director, Institute of Bio-Imaging for Bio-Medical Imaging Research
Director, Laboratory of Excellence TRAIL
Department Head of Neuro-Imaging
University of Bordeaux & University Hospital of Bordeaux

Lecture 2

Advanced MSK Techniques at 3T, Translational Application

Christine Chung, MD.
Professor of Radiology
Director, UCSD Musculoskeletal Imaging Research Group, UC San Diego
Vice Chairman of Academic Affairs, UCSD Department of Radiology

Lecture 3

New Horizons in Cardiovascular MR at 3T

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Lecture 1

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Dr. Dousset is a professor of medical imaging at the University of Bordeaux in France. He is also affiliated with the University Hospital of Bordeaux, where he heads the Department of Neuro-Imaging and serves as Director of their research institution, TRAIL. In addition, he is a member of the research team on neuroplasticity at the French National Institute of Health and Medical Research (INSERM). Dr. Dousset is involved in translational research focusing on nerve inflammation and has published more than 130 academic papers. In addition, he has been awarded the Lucien Appel Prize by the European Society of Neuroradiology and the Outstanding Teacher Award in medicine by ISMRM.

Usefulness of DLR

One of the "pain points" that has recently emerged in the field of MRI is an increase in the number of examinations and the resulting demand for shorter examination times. Among the solutions that have been proposed, the main approaches involve using a higher magnetic field intensity, increasing the gradient field strength, selecting the optimal pulse sequence, and performing high-speed postprocessing.

Our research system (Vantage Galan 3T ZGO) can reduce the time required for a routine head MRI examination to less than 4 minutes by employing a gradient field strength of 100 mT/m (Figure 1). In addition, the system supports AI-based Deep Learning Reconstruction (DLR) as a new method for achieving a high SNR while maintaining excellent spatial resolution. This DLR technology is designed to selectively remove noise without affecting the visualization of small structures and small differences in contrast by learning to identify the noise components in MR images through a Convolutional Neural Network (CNN). DLR can be used to achieve a short scan time while maintaining high image quality and good diagnostic performance. For example, we have succeeded in reducing the time required for high-resolution imaging techniques such as 3D FLAIR to about one-third: from 4 minutes and 54 seconds to 1 minute and 45 seconds (Figure 2). We have also confirmed that when DLR is applied to DWI, as a representative functional imaging technique, the ADC value (one of the biomarkers in DWI) is maintained at a level comparable to that in DWI without DLR.

In addition, Synthetic MRI using Olea Nova™+ is available as an approach for shortening scan times by performing postprocessing. By combining a scan

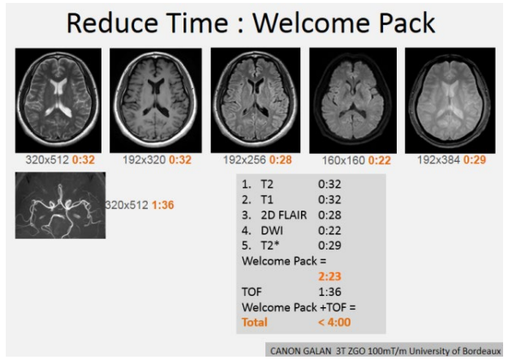


Figure 1

performed using the MP2RAGE sequence to generate a T1 map with a scan performed using the FSE multiecho sequence to generate a T2 map and then retrospectively adjusting multiple parameters, different types of contrast images, including T1W, T2W, and Double IR images, can be obtained as computed images. Because this feature makes it possible to shorten scan times, it has been found to be very useful in clinical practice.

The time saved in routine scanning can be used to perform additional scanning, such as other types of contrast imaging, Quantitative Susceptibility Mapping (QSM), Chemical Exchange Saturation Transfer (CEST), and Magnetization Transfer (MT), which I will discuss later.

Clinical applications of DLR

For imaging of the hippocampus, in which high resolution and thin slices are required, the use of DLR increases both the spatial resolution and the SNR, which makes it possible to obtain clinically useful images with a high spatial resolution comparable to that expected for a 7-T system. In particular, images with 0.4-mm isotropic resolution can be obtained in DWI, allowing the 3D observation of smaller functional structures (Figure 3).

Other clinical applications of DLR may include the visualization of the pituitary gland with 0.3-mm^3 resolution using FSE3D, the discrimination of various structures in the thalamus using an approach based on DIR-based White Matter Nulling (Figure 4), and the depiction of the structure of the semicircular canals using FASE3D.

Quantitative approach using DLR

There are high expectations for the application of DLR to QSM, CEST, and MT as quantitative approaches. For MT, it has been confirmed that the use of DLR can significantly improve image quality without affecting measurements (Figure 5).

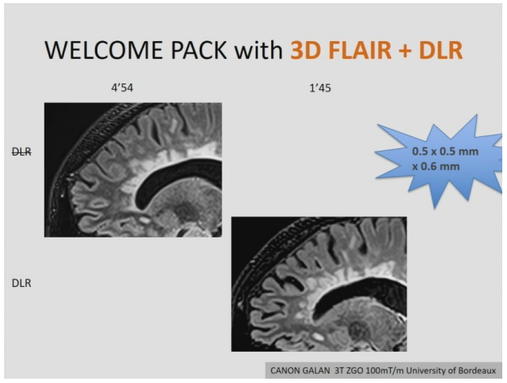


Figure 2

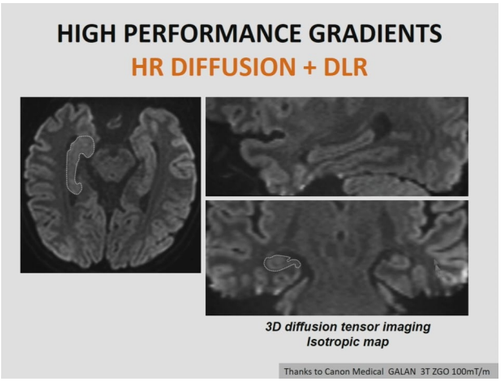


Figure 3

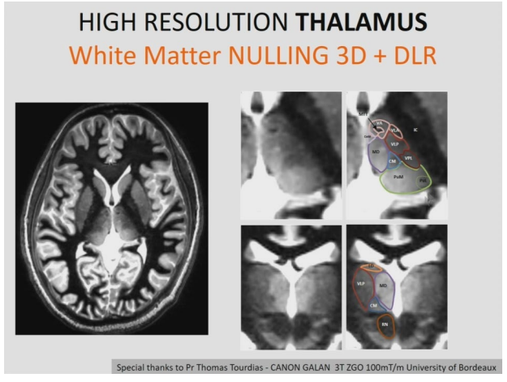


Figure 4

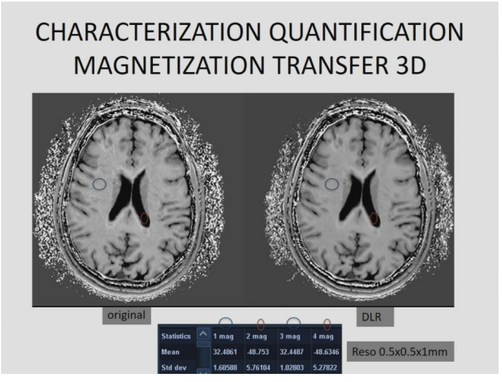


Figure 5

Conclusion

We feel that DLR is a promising new technology for future clinical applications, not only because of the shorter scan times but also because of the improved image quality and quantification.

Lecture 2

Advanced MSK Techniques at 3T, Translational Application

Christine Chung, MD.
Professor of Radiology
Director, UCSD Musculoskeletal Imaging Research Group, UC San Diego
Vice Chairman of Academic Affairs, UCSD Department of Radiology

Christine Chung, MD, is a professor in the Department of Radiology at the University of California San Diego (UCSD) in the United States. She also serves as Director of the MSK Imaging Research Group and Vice Chairman of Academic Affairs in the UCSD Department of Radiology. Her research interests include the detailed visualization of MSK tissues, the evaluation of tissues with a short T2, and the use of potential biomarkers in qMRI. She has published more than 170 academic papers, has been awarded NIH and VA grants, and has received the President's Medal of the International Skeletal Society. As a Fellow of the ISMRM and a previous Chair of the Program Committee of the ISMRM, she is one of the world's leading MSK radiologists.

Usefulness of CS in the MSK field

Clinical demands in the MSK field include the acquisition of high-quality images in a short time in order to enhance patient comfort and improve workflow, as well as the acquisition of still images of articular structures within their range of motion (ROM). In order to meet these demands, we have been performing verification using Compressed Sensing (CS) and DLR.

Canon Medical's CS technology, which combines Parallel Imaging (PI) with CS by employing Multi Sensitivity maps, allows CS imaging to be performed with a higher speedup factor and more stable unfolding ability in reconstruction processing. Let me show you some knee images as an example of imaging that does not depend on the sensitivity distribution of the coil. Fat-suppressed T2W images with a resolution of 0.3 mm or better can be obtained in the axial/sagittal/coronal planes in less than 1 minute without adversely affecting the contrast in the cartilage (Figure 1).

In addition, this CS technology enables 3D acquisition with a speedup factor of 6 in T1W and a speedup factor of 4 in fat-suppressed T1W, as compared to conventional acquisition with a SPEEDER factor of 2 (Figure 2).

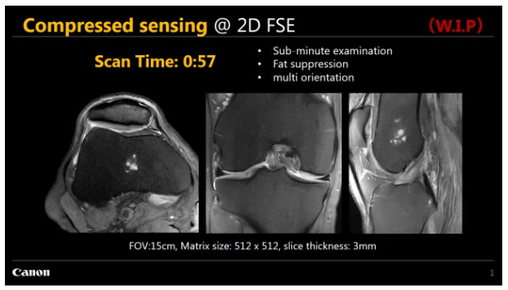


Figure 1

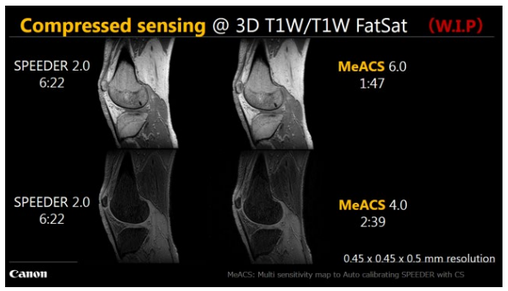


Figure 2

Use of DLR for the evaluation of TMJ function

In kinetic MRI studies of the temporomandibular joint (TMJ), it is necessary to observe the positional relationships between the condyle and the fossa in order to evaluate occlusion.

Verification using DLR showed that the SNR of FSE images acquired in 1.5 minutes was increased by a factor of about 6 after DLR processing, making it possible to evaluate engagement between the condyle and fossa. It was demonstrated that the positional relationships between the condyle and the fossa could be clearly observed in images of a healthy volunteer as well as images of a patient with temporomandibular joint dysfunction (TMD), both of which were acquired in a short scan time.

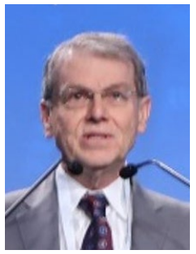
It is also possible to perform dynamic scanning to observe joint movement. While it may be easy to understand the structure of large joints such as the shoulder joint, it can be very difficult to clearly understand the structure of small joints such as the TMJ. However, 3D visualization and the use of DLR have made it possible to observe the movement of joints at a high frame rate, providing more detailed information concerning joint movement.

Conclusion

The use of DLR not only helps to ensure accurate diagnosis but also allows imaging of regions that cannot be observed using conventional techniques. We feel that DLR is able to provide extremely valuable information for treatment planning.

Lecture 3

New Horizons in Cardiovascular MR at 3T



João A.C. Lima, MBA, MD.
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School of Medicine and Bloomberg School of Public Health
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Johns Hopkins University

Dr. João A.C. Lima is a professor of medicine, radiology and epidemiology at Johns Hopkins University in the United States. He has authored or co-authored more than 500 academic papers and has served as a member of many boards responsible for formulating various CT and MRI guidelines. Of the many studies he has been involved with, those based on the use of MESA (Multi-Ethnic Study of Atherosclerosis) data are particularly well known. These studies have focused on the usefulness of various types of biological information for predicting the risk of developing arteriosclerosis and heart failure.

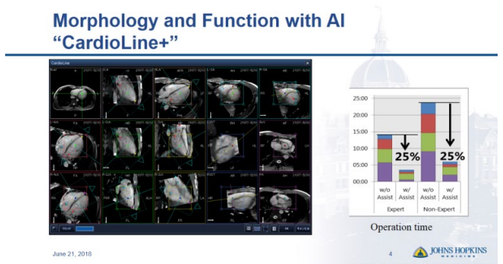
Use of AI in cardiac imaging

In cardiac imaging, it is essential to acquire cine images for the morphological and functional evaluation of the heart. However, scan positioning is very difficult in cardiac examinations, often resulting in a long scan time and poor reproducibility. Our study has confirmed that the use of CardioLine+, which employs AI, reduces the operation time to about one-quarter, even in examinations performed by unexperienced operators, and also allows cardiac imaging to be performed with better reproducibility (Figure 1).

Cardiac imaging using DLR

It is also important to acquire high-quality perfusion and LGE images as one step in cardiac imaging. The use of DLR increases the SNR in high-resolution MRCA images as compared to conventional scan techniques, allowing the coronary arteries to be clearly depicted. In addition, detailed anatomical information can be obtained in Black Blood images and cine images with the use of DLR (Figure 2).

T1 mapping, which is useful for detecting fibrosis and can even be used to evaluate diffuse diseases, is very important in cardiac MRI examinations because it helps to improve quantification and reproducibility. In T1 relaxation measurement, original images with a higher SNR can be expected to provide more accurate calculation images. On the other hand, there has been some concern that DLR processing may lead to errors in the resulting T1 map. Our study has confirmed that the use of DLR causes almost no changes in T1 values both before and after the use of contrast medium and also increases the uniformity of the map.



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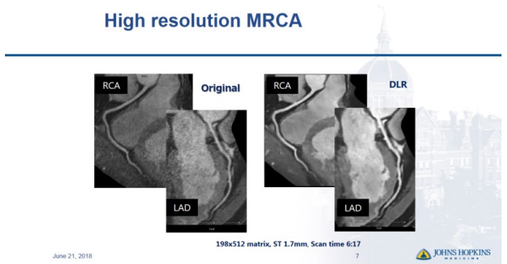

Figure 2

We also evaluated the use of Ultrashort TE (UTE), which provides excellent depiction of tissues with a short T2*, in cardiovascular and myocardial imaging. The results showed that contrast in the myocardium and aortic wall was enhanced by using a Dark Blood prepulse to eliminate blood-flow signals in the cardiac chambers. Because image quality can be significantly improved with the use of DLR, we are planning to employ UTE for the visualization of fibrosis (Figure 3).

Figure 3

Evaluation of the effects of aging using whole-body non-contrast MRA

In order to evaluate the effects of aging, I am currently involved in a project in which evaluation is performed based on the comparison of whole-body non-contrast MRA images and Water Fat Separation images. I am also planning to perform verification using selective angiography of the coronary arteries, renal arteries, etc. to investigate the processes involved in aging.

Conclusion

The results of this study showed that the use of AI technology in cardiac MRI can be extremely helpful in improving examination reproducibility and accuracy. We hope that DLR will undergo further development to become an even more valuable feature.

* This seminar report is based on lectures presented at a luncheon symposium held during ISMRM 2018.

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