Outstanding DWI diagnostic performance with *syngo* RESOLVE
Diffusion-Weighted Imaging

The diffusion rate of water molecules in different tissues correlates with their physiological state, and may be altered in disease.

Diffusion-weighted imaging (DWI) enables visualization and measurement of abnormal diffusivity, revealing lesions which may go unnoticed with conventional anatomical MR or CT imaging alone. The practical clinical value of DWI is well established. Despite some challenges in certain body regions, particularly at higher field strengths, DWI is now broadly used in clinical routine.

syngo RESOLVE

syngo RESOLVE is a revolutionary new approach for obtaining high quality DWI images even in body regions strongly affected by susceptibility artifacts.

The clinical impact of syngo RESOLVE has been shown in a variety of examinations, including the brain, skull base, spine, breast, prostate, pelvis and rectum. syngo RESOLVE can be particularly useful in the evaluation of smaller lesions especially in regions strongly affected by susceptibility artifacts. Compared to alternative methods (see glossary, p.17), syngo RESOLVE brings the best balance of imaging speed and quality.
**syngo RESOLVE – readout segmentation of long variable echo-trains**

Experience a higher level of diagnostic confidence with sharp, high-resolution diffusion-weighted images largely free of geometric distortions.

**Applications**

- Applicable in a variety of challenging body regions including brain, skull-base, spine, breast, pelvis and prostate

**Advantages**

- High-quality, high-resolution DWI and DTI
- Reduced susceptibility and blurring artifacts
- Insensitivity to motion-induced phase errors
- Reduced SAR in comparison to TSE-based methods

**Technical specifications**

- Readout-segmented, multi-shot EPI for reduced TE and encoding time
- Motion correction with 2D phase navigator and real-time image reacquisition for unusable data

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Conventional DWI  syngo RESOLVE

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Nagoya University School of Medicine, Nagoya, Japan
MAGNETOM Verio

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**High Resolution Diffusion-Weighted Imaging Using Readout-Segmented Echo-Planar Imaging, Parallel Imaging and a Two-Dimensional Navigator-Based Reacquisition**

David A. Porter,* and Robin M. Heidemann²

Neuroimaging
Hippocampal lesion

Conventional DWI

syngo RESOLVE

T2 TSE, GRAPPA 2, matrix 576, SL 2 mm
b1000 and ADC map, GRAPPA 2, matrix 160, TA 0.03 s/slice
b1000 and ADC map, GRAPPA 2, matrix 384, TA 0.05 s/slice

Ebara Hospital, Tokyo, Japan
MAGNETOM Trio, A Tim System
Brain tumor

T1 3D SPACE, GRAPPA 2, post-contrast

3D SPACE DIR, GRAPPA 2

syngo RESOLVE, b0, b1000 and ADC map, GRAPPA 2, matrix 188, TA 5:25 min

syngo RESOLVE, b0, b1000 and ADC map, GRAPPA 2, matrix 210, TA 5:18 min

IRM Francheville, Périgueux, France
MAGNETOM Aera
Spine
Post accident, TH6 and TH12 fracture

T2 TSE, GRAPPA 2, matrix 384
Singapore General Hospital, Singapore MAGNETOM Avanto

Conventional DWI
b650, ADC map and T1 TSE fused with b0 image, GRAPPA 2, matrix 128, TA 0.05 s/slice

syngo RESOLVE
b650, ADC map and T1 TSE fused with b0 image, GRAPPA 2, matrix 150, TA 0.02 s/slice
“synco RESOLVE is a useful sequence for acquiring high-quality diffusion-weighted images thanks to the reduction of susceptibility distortion, reduction of T2* blurring, shorter TE (and hence high SNR), and robust correction for motion induced artifacts.”

Prof. Dr. Julien Cohen-Adad,
MGH Martinos Center, Charlestown, USA /
École Polytechnique de Montreal, QC, Canada
Body Imaging

Breast Carcinoma

University Hospital, Kyoto, Japan
MAGNETOM Verio

AKH, Vienna, Austria
MAGNETOM Trio, a Tim system
Prostate Carcinoma

T1 TSE, GRAPPA 2

Conventional DWI

syngo RESOLVE

T2 TSE, GRAPPA 2

b0, b1000 and ADC map, GRAPPA 2, matrix 160, TA 0.04 s/slice

b0, b1000 and ADC map, GRAPPA 2, matrix 192, TA 0.03 s/slice

National University Hospital, Singapore
MAGNETOM Skyra
“*syngo* RESOLVE provides two very important advantages in comparison to conventional DWI sequences. First, RESOLVE gives ADC maps with significantly higher spatial resolution on a smaller FoV. Second, it eliminates the susceptibility artefacts at the interfaces between the endorectal coil, the rectal wall, and the prostate. This significantly improves diagnostic confidence in the peripheral zone, the key region of interest. Therefore, for examinations performed with the endorectal coil, *syngo* RESOLVE is one of the main tools to delineate the lesion contour and define the target for biopsy.”¹

Pr. Marc Lemort  
Jules Bordet Institute  
Brussels, Belgium

¹ National University Hospital, Singapore  
MAGNETOM Skyra
Conventional DWI

b0, b1000 and ADC map, GRAPPA 2, matrix 192, TA 0.03 s/slice

syno RESOLVE

b0, b1000 and ADC map, GRAPPA 2, matrix 192, TA 0.03 s/slice
Pediatric Imaging²

Medulloblastoma
12 year old male

Children's MRI Centre, Royal Children's Hospital, Melbourne, Australia
MAGNETOM Verio
Drop metastases to the spine
2 year old female
High-Resolution DWI in Brain and Spinal Cord with syngo RESOLVE

Julien Cohen-Adad

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A. A. Martinos Center for Biomedical Imaging, Massachusetts General Hospital, Harvard Medical School, Charlestown, MA, USA

Abstract

In this paper we present some applications of the syngo RESOLVE sequence that enable high-resolution diffusion-weighted imaging. The sequence is based on a readout-segmented EPI strategy, allowing susceptibility distortions and T2* blurring to be minimized. The RESOLVE sequence can be combined with other acquisition strategies such as reduced field-of-view (FOV) and parallel imaging, to provide state-of-the-art tractography of the full brain and cervical spinal cord. The RESOLVE sequence could be of particular interest for ultra high field systems where artifacts due to susceptibility and reduced T2 values are more severe. At all field strengths, the sequence promises to be useful in a number of clinical applications to characterize the diffusion properties of pathology with high resolution and a low level of image artifact.

1. Introduction

1.1. Diffusion-weighted imaging

Diffusion-weighted MRI makes it possible to map white matter architecture in the central nervous system based on the measurement of water diffusion [11]. The technique works by using MRI sequences that are sensitized to the microscopic motion of water molecules, which are in constant motion in biological tissues (Brownian motion). Using the well-known pulse sequence introduced by Stejskal and Tanner in 1965 [29], it is possible to quantify the extent of water displacement in a given direction. This sequence consists of magnetic field gradient pulses (diffusion-encoding gradients) that are applied before and after a 180° radiofrequency (RF) refocusing pulse. The first gradient pulse dephases the precessing nuclear spins that generate the signal in MRI. In the theoretical case of static molecules, the second gradient pulse completely rephases the spins and there is no attenuation due to the application of the gradients. However, if water molecules move during the application of this pair of gradients, spins are dephased and signal decreases as a function of the magnitude of the displacement, leading to a so-called diffusion-weighted signal. The magnitude by which the signal is weighted by diffusion is dictated by the so-called b-value, which depends on the length and amplitude of the applied diffusion-encoding gradients, as well as the duration between the first and the second gradient pulse (also called diffusion time). By applying diffusion gradients in various directions (e.g., 20 directions equally sampled on a sphere), it is possible to estimate the rate and direction of water diffusion. For example in pure water, molecules diffuse equally in all directions, hence the diffusion is described as isotropic. Conversely, in mesenchymal structures such as the white matter or muscles, water diffuses preferentially along the direction of the fiber. In such a case, the diffusion is anisotropic [3].
Benign versus metastatic vertebral compression fractures: combined diffusion-weighted MRI and MR spectroscopy aids differentiation

Helmut Rumpel · Yi Chong · David A. Porter · Ling L. Chan

Eur Radiol, 23(2), 541-550, 2013

Diffusion-weighted read-out-segmented echo-planar imaging improves spinal image quality.
CASE REPORT

Drop metastases to the pediatric spine revealed with diffusion-weighted MR imaging

Laura L. Hayes · Richard A. Jones · Susan Palasis · Dolly Aguiler · David A. Porter

Abstract

Identifying drop metastases to the spine from pediatric brain tumors is crucial to treatment and prognosis. MRI is currently the gold standard for identifying drop metastases, more sensitive than CSF cytology, but imaging is not uncommonly inconclusive. Although diffusion-weighted imaging (DWI) of the brain is very useful in the evaluation of hypercellular tumors, DWI of the spine has not been clinically useful in children because of susceptibility artifacts and lack of spatial resolution. A new technique, readout-segmented echo planar imaging (EPI), has improved these images, allowing for identification of hypercellular drop metastases. We report a case that illustrates the utility of spine DWI in the detection of metastatic disease in children with primary central nervous system (CNS) tumors. This case suggests that DWI of the spine with readout-segmented EPI should be included in the evaluation for drop metastases.

Keywords

Spine tumor. Diffusion-weighted imaging. MRI. Readout-segmented EPI

Introduction

Diffusion-weighted imaging (DWI) of the spine reveals drop metastases that might not be visible on conventional sequences in children with hypercellular brain tumors. We report a case that illustrates the utility of spine DWI in the detection of CSF-disseminated metastases in children with primary central nervous system (CNS) tumors.

Case report

IRB approval was obtained for this report. A 2-year-old girl with an atypical teratoid rhabdoid tumor (ATRT) of the posterior fossa presented for a routine follow-up MRI scan of the brain and spine. At the time of diagnosis, her primary tumor demonstrated restricted diffusion on MR and heterogeneous enhancement with gadolinium. She had no evidence of drop metastases to the spine. Subsequently, she underwent gross total resection, and was treated with intrathecal and intravenous chemotherapy in addition to posterior fossa radiation. She was negative for residual disease for 16 months. She was off treatment for 3 months and asymptomatic with negative CSF cytology at the time of the follow-up study. Her MRI scan, performed on a 1.5-T Avanto system (Siemens Medical Systems, Erlangen, Germany), revealed a single nodular focus of restricted diffusion along the dorsal aspect of the spinal cord in the mid-thoracic region (Fig. 1). There was no corresponding signal abnormality or abnormal enhancement at this location. Because of the diffusion abnormality, a conservative approach was taken.

Readout-segmented echo-planar imaging reached a higher diagnostic accuracy for the differentiation of benign and malignant breast lesions.
# Glossary: Diffusion-weighted techniques

| **syngo RESOLVE**<br>(readout-segmented EPI) | A readout-segmented, multi-shot EPI sequence where the k-space trajectory is divided into multiple segments in the readout direction, reducing TE and encoding times to increase image quality. *syngo* RESOLVE provides high-quality, high-resolution, distortion-minimized DWI of challenging body regions, including the skull base, spine, breast and pelvis. High-resolution DTI imaging can also be achieved for the brain and spine. Motion correction is performed using a 2D navigator to correct for motion-induced, non-linear phase errors. Robust image quality is further enhanced by the use of a real-time navigator-based reacquisition technique to replace uncorrectable data with severe phase errors. Imaging can be performed in all orientations and the sequence is compatible with parallel imaging, providing a further reduction in susceptibility-based distortions. |
| **Single-shot EPI** | The sequence conventionally used in clinical imaging which samples the entire k-space in a single readout. While fast and relatively motion-insensitive, it is prone to susceptibility artifacts at tissue interfaces, especially at higher field strengths. Spatial resolution is limited by the T2* decay during the long readout time. Image distortion makes it particularly difficult to achieve diagnostic DWI of the spine. |
| **Phase encode segmented EPI**<br>(interleaved EPI) | Multi-shot EPI with segmentation applied in the phase-encoding direction, so that all readout points are sampled at each shot, but with a reduced number of phase encoding points. While the sequence can provide higher spatial resolution and imaging in all orientations, the sampling scheme used cannot be easily combined with 2D, non-linear, navigator phase correction. As a consequence, when combined with diffusion-weighting, the sequence is prone to motion-induced aliasing artifacts. Spine DWI is of insufficient image quality and it remains to be seen if high quality DTI can be enabled. |
| **BLADE diffusion**<br>(TSE-based) | For this sequence, the k-space is sampled in a radial fashion. Images may be high-resolution and relatively motion-insensitive. However, the acquisition time may be comparatively long and imaging can only be acquired in the axial plane. Spine DWI is of insufficient image quality and it remains to be seen if high quality DTI can be enabled. |
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2 MR scanning has not been established as safe for imaging fetuses and infants under two years of age. The responsible physician has to decide about the benefit of the MRI examination in comparison to other imaging procedures.