Spine MRI Artifacts: Emerging Solutions

Session: Emerging Spine Techniques

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Target Audience: Clinicians, researchers and technologists interested in spine MRI

Background: Spinal MRI is a useful diagnostic tool for detecting degeneration and/or abnormalities of the spine and its adjacent anatomies. Its strength lies in its ability to provide visualization of the spinal cord, nerve roots, intervertebral disc and the vertebral bone marrow with non-ionizing radiation in a non-invasive way. In comparison, radiation exposure can be considerable from computerized tomography, especially in the lumbar spine; and myelography which involves puncture and contrast injection is quite invasive [1]. But unlike brain MRI which has advanced in leaps and bounds over the last decade, progress in spinal MRI has been less spectacular. While some promising new spine MR techniques such as sodium MRI [2], functional MRI [3] and quantitative magnetization transfer in the spinal cord [4], T1ρ mapping in the intervertebral disc [5] etc. have been presented in the past few years, consistent and robust execution of bread and butter clinical spine MRI protocols still remains a challenge.

Purpose: The purpose of this talk is to discuss some of the most prevalent sources of artifact in spine MR images and to highlight a few emerging techniques that aim to address these issues. Because of anatomical and physiological differences between the cervical, thoracic and the lumbar spine, the sources of MR image artifacts also vary between these regions.

A standard spine exam typically consists of two dimensional (2D) T1, T2 and/or T2* weighted sagittal and axial scans. Some scans might be acquired after the intravenous administration of a paramagnetic MR contrast agent to detect regions of vascular abnormality. Depending upon the symptom being investigated, the exam might also include functional techniques such as diffusion weighted imaging (DWI) [1]. Unlike adult brain MRI protocols which are primarily volumetric, adult spine MR protocols mostly consist of two dimensional scans because of motion and other concerns.

<u>B0 inhomogeneity induced artifacts:</u> Static magnetic field inhomogeneity poses a technical challenge in spine MRI. The bone-soft tissue interfaces and trabecular bone cause distortions in the magnetic (B0) field. In the thoracic spine (Tspine), the field distortion is exacerbated by the presence of the adjacent air cavity. This results in distortion, “blooming” or artifactual enlargement of vertebral processes, signal drop out, signal pile-up and other intensity variations in the MR image [6]. The most common method of improving B0 homogeneity is to apply a localized linear shim over the region of interest. More advanced shimming techniques such as higher order and dynamic shimming could potentially help achieve a more homogeneous magnetic field. Reduced field-of-view (rFOV) using 2D spatially selective RF excitation is another approach that can excite a small extent in the phase field of view (FOV) direction. In this way, sources of artifact such as the lung cavity can potentially be avoided in the excitation FOV, and distortion can further be reduced by shortening of the echo-train length. Reduced FOV DWI using 2D

spatially selective RF excitation with the echo-planar sequence has demonstrated significantly improved image quality and high resolution in the spine. [7, 8].

Poor fat suppression: The local B0 variation and the steep magnetic susceptibility gradient at tissue interfaces cause broadening and shifting of the resonant frequency peak leading to poor performance of the frequency selective fat suppression. Short tau inversion recovery (STIR) can suppress fat signal more completely, but comes at the expense of signal-to-noise ratio (SNR). Multi-point Dixon based methods can provide a robust fat suppression even in problem regions such as the brachial plexus [9, 10].

Artifacts in presence of metal implants: Presence of surgical metal implants in post-operative subjects present a case of extreme magnetic field inhomogeneity where the resulting images are often deemed diagnostically unusable. Recently published view angle tilting approaches such as multi-acquisition with variable resonance image combination (MAVRIC) and slice-encoding metal artifact correction (SEMAC) techniques have significantly reduced artifacts and improved visualization of anatomy near embedded metal hardware by applying alternative spectral and spatial-encoding schemes to conventional spin-echo sequences. [11,12].

Motion and pulsatility induced artifacts: Physiological motion such as Cerebrospinal fluid (CSF) pulsation, respiration, blood flow can manifest as ghosting, streaking or signal voids in the spinal MR image and interfere with diagnosis [13]. Additionally, swallowing is also a major source of artifact in the Cspine. Increasing the number of averages or switching phase encoding direction so that it is not aligned with the direction of flow are simple protocol choices made to reduce motion artifacts. Gradient moment nulling methods are frequently used to reduce artifacts arising from CSF pulsation [14]. Gating methods such as respiratory and cardiac gating can be used to synchronize acquisition with physiological motion but this comes at the expense of scan time [15]. The periodically rotated overlapping parallel lines with enhanced reconstruction (PROPELLER) /BLADE technique in which the center of k-space is sampled repeatedly in every echo-train has been shown to effectively reduce motion induced by both physiological motion and swallowing [16]. In some applications, it might be of interest to study rather than suppress the CSF flow. In such an application, phase contrast MRI might be used with cardiac gating [17].

Among other emerging techniques, use of parallel transmit technology (“RF shimming”) to reduce shading artifacts caused by B1 homogeneity [18] and simultaneous multi-slice excitation to improve T1 contrast [19] will also be briefly discussed.

Reference

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