The FSE Cusp Artifact: A Phase Wrap-In Artifact Seen on Routine Clinical MR Images of the Knee

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Introduction

In the course of routine fast spin echo (FSE) magnetic resonance (MR) imaging of knees, we have noticed a distinct and recurrent artifact on MR sagittal knee images. The artifact usually appears as a local dot of high signal intensity and/or c-shaped ripples at a non-orthogonal angle (Figure 1).

The technical features of this artifact have been previously described in an ISMRM abstract in 1995, when the artifact was termed the FSE “cusp” artifact [1].

In the course of our investigation, we have found that the FSE cusp artifact has a high prevalence in clinical MR images of the knee and that it can occasionally obscure anatomic detail that is required for clinical evaluation and diagnosis. We have additionally noted a similar FSE artifact in the presence of metal implants (Figure 2).

Despite its prevalence, however, the FSE cusp artifact is still not well known. In this abstract, we describe the origin, nature, clinical prevalence, and methods for management of the FSE cusp artifact when it is encountered clinically.

The FSE Cusp Artifact

The FSE cusp artifact is produced from a combination of RF, main magnet, and gradient coil factors. Outside the imaging volume, B0 inhomogeneity and gradient coil rolloff can create large regions with magnetic fields similar to those within the imaging volume. Excitation in these regions still occurs due to residual RF coil sensitivity. Subsequently formed transverse magnetization maps onto the final desired image, creating the cusp artifact.

The mapping of weak, encoded signal from a large region into a smaller region of the final image creates the appearance of the cusp artifact. If the extraneous transverse magnetization undergoes spatial encoding, it creates a phase interference pattern (Figure 1) when superimposed onto the desired image (c-shaped ripples). The origin of a similar FSE artifact occasionally found near small metal implants is also due to the superposition of extraneous signal (Figure 2).

The FSE imaging sequence is sensitive to this wrap-in effect because 1. Carr-Purcell-Meiboom-Gill (CPMG) conditions are maintained by the FSE k-space pathway, creating a wider range of tip angles that will result in echo signals than spin-echo (SE) imaging, and 2. Shorter intervals between excitations increase the likelihood of extraneous signal formation in FSE versus SE imaging.

Phase encoding in the cranial-caudal direction is particularly liable to creating the FSE cusp artifact. This is due to an increased amount of tissue that can be excited outside the imaging volume during section selection.

If phase cycling the 90 degree pulse of a CPMG sequence is used within an odd-numbered NEX acquisition, two wrap-in cusp artifacts, separated by a distance of half the field of view (FOV), can arise from these causes [1]. Phase over-sampling (no phase wrap) only eliminates one of these artifacts.

Prevalence in Clinical MR Images

In a retrospective examination of 55 consecutive MR knee studies from our institution (29 left knee, 26 right knee), we found evidence of the FSE cusp artifact in 41 cases (74%). In clinical knee images, the FSE cusp artifact predominantly appears on sagittal FSE images, and only if phase encoding is oriented cranial-caudally.

In addition, the FSE cusp artifact was consistently found only on MR images of the medial aspect of patients’ knees. Low gradient strength regions outside the imaging volume are most likely to create extraneous signal that would map onto final images. Corresponding regions within the imaging volume, such as medial knee compartments, are near the isocenter.

The cusp artifact can appear anywhere within the image. In a number of cases, the cusp artifact has obscured portions of the knee image required for diagnosis.

Not surprisingly, we have further noted the artifact on FSE images of other parts of the body that use cranial-caudal phase encoding e.g. MR images of the spine.

We have also noted that the cusp artifact is manufacturer independent, and that we have seen examples of the FSE cusp artifact on images from MR imaging systems from different manufacturers at a number of institutions.

Managing the FSE Cusp Artifact

We suggest a few simple strategies to eliminate or manage the FSE cusp artifact after acquisition of routine MR knee images. 1. Changing the FOV by a few cm moves the artifact. 2. Moving the patient also moves the artifact position. 3. Swapping gradient moves and may reduce the artifact. 4. Alternating the polarity of the section selection gradient moves and may reduce the artifact.

Summary

This abstract describes a small FSE-related wrap-in artifact that is found frequently on routine clinical MR images of the knee. While usually of no consequence, it can sometimes obscure anatomical details that are needed for diagnosis. The etiology of this artifact, its clinical prevalence, and simple methods for management of the artifact are described.

References