

# Motion Artifacts & Practical Solutions: Physical Basis for Motion Artifacts

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## Objectives:

- Derivation of MR signal equation under general patient motion.
- Classification of different types of motions and description of their manifestations in MR images.
  - Periodic (cardiac, respiratory, flow) and non-periodic (head) motion.
- Examples of common motion artifacts

## Introduction

Due to the sequential nature of MRI data acquisition, patient motion has detrimental effects on the MR images. Especially during the imaging of certain populations, such as children, elderly, patients suffering from certain medical conditions (e.g. Parkinson's, stroke), correction of patient motion becomes essential for diagnostic image quality. Even during imaging of healthy populations, one needs to address artifacts arising from cardiac, respiratory, peristaltic motion or flow. In this session, we will begin by laying out the physical description of MR data acquisition in the presence of motion. Then, the appearance of motion artifacts under different MRI data acquisition strategies will be discussed. At the end of this talk, the audience will be able to recognize and describe the physical basis of common motion artifacts seen in MRI.

## Theoretical Background

Motion results in the breakdown of the Fourier relation between the image and the acquired raw MR data (1). Specifically, under general motion, the anatomy under examination will be different for each time point, which will result in an inconsistency in the acquired k-space data. Thus, without any correction, the final reconstructed MR-image will be the sum of the aliased versions of the MR image at different time points. In this part, the modified MR signal equation that includes the effects of general patient motion will be shown (2-4). The emphasis will be on the readout of the raw MR data and the effects of motion on excitation will be ignored. It will be shown that the aliasing artifacts will be different for different types of readouts, i.e., ghosting for Cartesian, swirling for spirals and streaking for radial acquisitions (5).

## Periodic Motion

Periodic motion is observed in all patient populations during abdominal and cardiac scans in the form of respiration, cardiac pulsation and blood flow. The motion artifacts observed in these studies depend on the acquisition method used, the periodicity of motion and the brightness of the structures creating the artifacts (6-8). View-to-view inconsistencies resulting from respiratory and cardiac motion appear as ghosts in the resulting images. High-velocity blood flow, especially in aorta, also results in a phase difference between different views of the k-space, which results in ghosting (i.e., zipper artifacts) or signal voids (9,10). In this part, the artifacts resulting from periodic motion will be described. We will also discuss intra-view motion which causes phase accumulation in flowing blood (11).

## Non-periodic Motion

The most common non-periodic motion seen in MR is head motion. Head motion cannot be corrected via gating or triggering since there's no guarantee that the pose of the head will return to its initial position. However, one advantage is that the head motion can be modeled as a rigid transformation, i.e., by 3 rotations and 3 translations. In this section, the MR signal equation in the presence of rigid head motion will be described (12,13). The appearance of head motion artifacts under different imaging techniques will also be shown.

## Conclusions

Correction of involuntary patient motion remains an unsolved problem in MR. Motion artifacts can appear during the scanning of different anatomies, and the appearance of motion artifacts varies depending on the acquisition technique and the type and amplitude of motion. Motion artifacts can render MR scans non-diagnostic and require repeat scans, which in turn decreases patient throughput and increases cost per exam. Thus, it is important to understand how motion artifacts arise, and recognize these artifacts for better diagnostic reliability.

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