Please Hold Still Next Time: Challenges & Solutions in Patient Adherence

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Highlights

- Involuntary patient motion remains a major problem in MRI
- Several solutions are available through scanner vendors and many more are under development in the research community
- MRI users have a 'toolbox' of tools to choose from, depending on the problem at hand
- Tools can be grouped into three categories: motion prevention, artifact reduction or motion correction

Title: VENDOR AND RESEARCH SOLUTIONS

Target audience: This presentation is aimed at (a) clinicians and scientists interested in using existing motion prevention, artifact reduction and motion correction tools and (b) researchers performing research into developing new tools.

Objectives and content summary: This presentation will loosely follow the content of a recent review article by Zaitsev, Maclaren and Herbst [1]. The fundamental principles leading to motion artifacts will briefly be covered. These principles will then be used to explain how current motion prevention, artifact reduction and motion correction tools function and in which situations each tool is most applicable. The aim of this presentation is to make the audience aware of the large range of tools that exist or are under development.

MRI has always been particularly sensitive to subject motion, partly due to the time required to collect sufficient data to form an image, but also due to the way data are acquired in k-space. Sensitivity to blood flow and diffusion can provide useful contrast information, but bulk motion is typically a major problem in clinical applications and is one of the most frequent sources of artifacts. There is no indication that an all-purpose motion correction method will be developed that can correct all motion in all organs and imaging situations. Rather, there is a toolbox of solutions, and it is up to the user to select the correct tool for the imaging task at hand.

Motion prevention is the most obvious approach used to avoid motion artifacts, and there are a number of tools available for this. Foam restraints are common and well tolerated. More elaborate methods include training children with a mock MRI or scanning infants after first feeding and wrapping them, to encourage sleeping. Sedation is sometimes used, as is general anesthesia, which is reportedly more effective than sedation, but is associated with greater costs and higher likelihood of adverse effects [2]. For cardiac and abdominal imaging, breath-holding is an effective method of preventing artifacts from breathing, but severely restricts scan duration.

Artifact reduction methods have been employed since the early days of MRI to reduce the effect of unpreventable motion on image quality [3]. Artifact reduction has been traditionally achieved using strategies such as shortening the imaging time, optimizing the phase/frequency-encoding directions and changing the view ordering. Breathing motion is generally periodic and so the acquisition can be timed using respiratory gating methods to maintain data consistency [4]. Motion insensitive k-space trajectories, such as spirals or radial trajectories, exhibit motion artifacts that are more benign than interleaved Cartesian imaging. Newer artifact reduction strategies include

parallel imaging [5]–[7], compressed sensing [8] and multi-slice imaging [9] to further shorten acquisition times.

Motion correction methods normally involve the explicit estimation and correction of motion and its effects. Several early implementations were developed in the 1980s and involved correction of mainly one-dimensional motion [10], [11]. Since then, dozens of new methods have been proposed, and several have made the transition into regular clinical use. Notable examples include PROPELLER [12] and, more recently, PROMO [13]. Many other techniques are the subject of current research and will be discussed further in this presentation.

Conclusion: The large range of motion types, k-space sampling trajectories and image contrasts used in MRI mean that there is no single motion prevention or correction tool that can be applied in all situations. Instead, users need to select from a toolbox of techniques, where different tools are applicable in different situations.

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