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Meeting abstract

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1074 Circumferential strain encoding of the left ventricle using CIRCOME: sequence, algorithm and factor analysis

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Introduction

Circumferential strain of the left ventricle reflects myocardial contractility and is considered a key index of cardiac function. It is also an important parameter in the quantitative evaluation of heart failure. Circumferential compression encoding, CIRCOME, is a novel method in cardiac MRI to evaluate this strain non-invasively and quickly. This strain encoding technique avoids the explicit measurement of the displacement field and does not require calculation of strain through spatial differentiation. CIRCOME bypasses these two time-consuming and noise sensitive steps by directly using the frequency domain (k-space) information from radially tagged myocardium, before and after deformation. It uses the ring-shaped crown region of the k-space, generated by the taglines, to reconstruct circumferentially compression-weighted images of the heart before and after deformation. CIRCOME then calculates the circumferential strain through relative changes in the compression level of corresponding regions before and after deformation. This technique can be implemented in 3D as well as 2D and may be employed to estimate the overall global or regional circumferential strain. Parameters that affect the accuracy of this method are spatial resolution, signal to noise ratio, eccentricity of the center of radial taglines and their density. Also, a variety of possible image reconstruction and filtering options may influence the accuracy of the method. This study describes the pulse sequence and algorithm of CIRCOME. It further evaluates influencing factors and limiting criteria for this method through the analytical calculations as well as simulated results.

Purpose

Left ventricular circumferential strain (LVCS) describes regional or global myocardial contractility. However, the calculation of strains usually comprises two steps: measuring the displacement field which needs time consuming imaging and post-processing methods, and performing spatial differentiation on that field which is a highly noise sensitive procedure. Therefore methods that bypass these two steps and measure the strain directly make the whole process faster and more robust. The purpose of this study is to introduce the pulse sequence and algorithm of such a method that encodes the circumferential strain simultaneously in several short axis (SA) planes by using the k-space information in radially tagged MR images. Further, we evaluate the feasibility and robustness of this technique through analysis of imaging parameters and simulated datasets.

Methods

In summary the CIRCOME method contains these steps:

1 – Tagging the short axis slices in the radial direction by appropriate modulation of the longitudinal magnetization.

2 – Acquisition of the ring-shaped crown region of the k-space, generated by the taglines in initial and deformed states.

3 – Reconstruction of one circumferentially compression-weighted image slice at each state by using narrow band-pass circular filters in the K-space.

4 – Calculation of the circumferential strain through relative changes in the compression level of corresponding regions before and after deformation. Using radial tags, corresponding regions can be automatically found without time consuming exact tissue tracking techniques.

The influence of the limiting factors including noise, resolution, eccentricity of the center of radial taglines and their inadequate density were quantified analytically and through the simulations.

Results

Feasibility of the technique was shown under the physical limitations of the clinical scanners. Further, images of the radially tagged myocardium before and after a deformation have been simulated. Using the described method a circumferentially compression-weighted image has been reconstructed for each image from its K-space data. Global circumferential strain was then determined by the relative shift of average compression level.

Conclusion

CIRCOME encodes the circumferential compression of the myocardium for several short axes planes simultaneously and in real-time. It robustly measures the global circumferential strain, without taking spatial derivatives. In combination with different MRI pulse sequences and simple region tracking algorithms it can also measure the regional circumferential strain.