

Adaption of HASTE for continuous moving table acquisition

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Synopsis

An axial whole body technique with continuous table movement supplying clinical T2-contrast or STIR-weighted images is presented. The acquisition is based on a single shot HASTE sequence. The established protocol is motion-insensitive and allows free breathing of the patient during the measurement. The protocol yields five independent sets of axial images for a gapless homogenous coverage of the whole human body. RF power deposition into the patient's body was drastically reduced by introduction of the hyperecho mechanism into a conventional HASTE using TRAPS.

Introduction

Currently, whole body imaging is becoming more and more popular [1-3]. Compared to multistation techniques moving table techniques have the advantage of a continuous imaging in which the whole body is scanned in a single measurement without temporal or spatial steps of the acquisition. Among all possibilities to choose from, axial imaging, where the slice is perpendicular to the moving direction provides maximum homogeneity in image intensity and contrast at a minimum of hardware and post-processing requirements [3]. It was shown that the motion insensitivity of rapid 2D acquisitions such as TrueFISP is highly valuable for imaging particularly of abdominal regions during free breathing [4]. However, TrueFISP sequences lack a well defined T1- or T2-contrast. In this work we established an axial imaging technique on the basis of a single-shot RARE with Half-Fourier-reconstruction (HASTE) in combination with a continuous table movement and hyperecho signal formation. A T2-weighted or alternatively STIR-contrast was achieved covering the whole human body during free breathing in a single measurement for medical screening and diagnosis.

Subjects and Methods

Three major items have to be considered for adapting a single shot HASTE-sequence to moving table acquisitions: a) Limiting SAR, b) spatial shifting of the position of the refocusing pulses within one echo train relative to the excitation pulse, c) successively acquired slices must have a certain mutual space to avoid cross talk between the slopes of the pulses and saturation artifacts. Considering an undefined motion due to respiration in opposite direction to the table movement requires an even increased slice separation. Contrary, it is not desirable to produce gaps due to widely spaced slices, especially in connection with a respiratory motion in the same

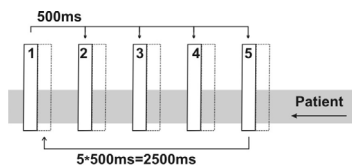


Fig.1: Chronological order of serial slice acquisitions

direction as the table motion. We solved these major concerns by the following experimental setup: First, the RF power was drastically reduced by modifying a conventional HASTE to a HyperHASTE-sequence using TRAPS [5]. For this, the refocusing flip angles were linearly ramped from 180° down to 60° to the end of the echo train. Therefore it was feasible to acquire multiple slices with a single shot technique in short repetition times. Second, during each TR=500ms one of five widely spaced slices (distance 24mm) was acquired, while the table moved with constant speed, as depicted in **Fig.1**. After the acquisition of five slices the table moved in total by exactly one slice thickness of 6mm (i.e. $v_{\text{table}} = 2.4\text{mm/s}$). By repeating this identical acquisition loop, five slices are acquired each adjacent to the former acquisition slices of the patient. This specific scheme of slice acquisition has three effects compared to a simple serial acquisition: First, the spatial shift between the refocusing pulses and the excitation pulse within one echo train is reduced to $1/5 \cdot \text{slice thickness}$. Second, the recovery time between the acquisition of two adjacent slices during the table motion is increased to $\text{TR}' = 5 \cdot \text{TR} = 2500\text{ms}$.

And third, repeating the described measurement procedure for 250 times, it yields to a five fold coverage of the whole body. Possible gaps between adjacent slices in one of the five axial sets containing 250 images are closed by the acquisitions of the other sets. The whole examination took about 10min. Other sequence parameters were: Matrix 256x179, FoV=40cmx30cm, BW=391Hz/Px, ESP=4.6ms, ETL=64, TE = 74ms. Alternatively, STIR-imaging was performed by means of an IR-preparation (TI=160ms). All experiments were performed on a whole-body imaging system at a field strength of 1.5T (Siemens Sonata, Siemens Erlangen, Germany) with use of local coil arrays for signal reception. The moving table (angiosurfTM) was controlled by a self-constructed RF shielded electrical drive. Written informed consent was obtained from each subject prior to the experiment. The study was approved by the local ethics committee.

Results

In **Fig.2** left side an original axial image is shown. In the middle a coronal reconstruction through one set of 250 axial T2-weighted HASTE images is displayed. The right coronal image is a MIP-reconstruction through the slice package acquired with the STIR-HASTE sequence. The achieved quality of the original, axial images is very close to the one of conventional images. Neither breathing artefacts nor saturation artefacts due to the excitation of neighbouring slices are observed. The spatial shift in the slice positions of the phase encoding steps within the same echo train does not result in visible image artefacts either. Notice the homogenous intensity profile along the human body in the coronal reconstruction images.

Discussion and Conclusion

The feasibility of whole body imaging by means of a continuous table movement providing conventional T2-weighted axial images was demonstrated. The employed single shot HASTE-sequence proved to be motion-insensitive to free breathing and table motion. No additional post-processing and correction of field distortions was necessary to achieve a homogeneous coverage of the entire human body. All images of the same set of slices were acquired at the same position within the scanner. For even faster table motions the frequencies of the refocusing pulses within one echo train can be synchronized with the table motion. Although a five-fold acquisition of the body should exclude any coverage gaps, an independent evaluation of the separate slice sets is certainly sub-optimal. Optimized reconstruction algorithms will be developed to combine the five sets of images. This will yield a better SNR and an even faster diagnosis. We believe that there is a bright future for the clinical setup presented in this acquisition technique. Our adaption of HASTE in connection with a continuous table movement, hyperecho signal generation and local coil arrays allow a clinical protocol for fast screening and medical diagnosis with T2 and/or T1-weighted contrast of the whole patient's body. This method already found enthusiastic acceptance at radiologists in our institution.

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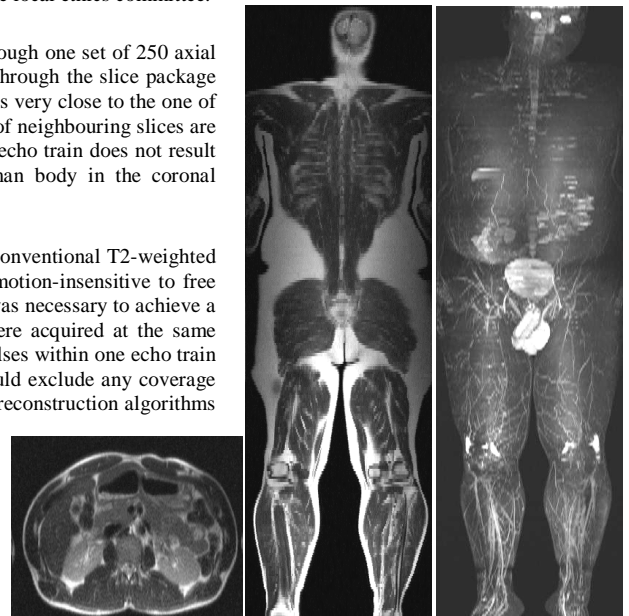


Fig.2: left : example of a T2-weighted axial image
center: example of a T2-weighted coronal reconstruction
right : MIP-reconstruction based on STIR-HASTE