Quiet MR Sequences for Routine Head Examinations: A Volunteer Study

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Introduction

Many patients suffer from the high acoustic noise accompanying an MR-examination. The sound originates from Lorentz forces in the gradient coils. With higher gradient strength and faster gradient switching times the noise usually increases (1-3). In this paper, we show results of quiet SE and TSE-sequences that are adapted for routine T_1w and T_2w head scans. Our aim was not to reduce the noise to a barely audible level as was done by Hennel (4). We rather developed sequences that are of significantly reduced acoustic noise levels and are applicable to routine tasks. We programmed gradients with sinusoidally shaped ramps and constant plateaus, both for the imaging gradients and a quiet water saturation module that is used to suppress inflow artifacts. We compared the T_1w and T_2w images of 12 healthy volunteers from the standard sequence, a variant of this sequence with 'whisper' gradients (also provided by the manufacturer) and three different variants of our quiet sequences.

Methods

T_1w and T_2w head images with standard imaging parameters were acquired from 12 healthy volunteers with a 1.5T scanner (Siemens Magnetom Sonata, Erlangen, Germany). For both weightings five different series were measured: a standard Siemens sequence, a corresponding 'whisper' protocol with reduced maximum slope and amplitude values and three different realisations of our quiet sequences. The quiet sequences were programmed with different ramp times for all gradients (1.4ms, 1.65ms and 1.9ms) and a sinusoidal instead of a linear gradient slope. The sequence parameters relating to geometry and resolution were kept fix. To ensure a fair comparison of signal-to-noise-characteristics, the bandwidth of the quiet sequences was chosen as close as possible to the bandwidth of the corresponding routine protocols. Two radiologists with different experience in diagnostic radiology evaluated the MRI scans in a consensus methodology. Both readers were blinded for the type of sequence they observed. Image quality was subjectively rated, first, concerning technical criteria such as grey level, image contrast and spatial resolution and, second, concerning the following morphological criteria: 1) differentiation of white and grey matter, 2) delineation of the internal capsule and subcortical nuclei and 3) detectability of pyramid fibres in the level of the medulla oblongata. The presence of possible susceptibility artefacts was encountered. Three regions of interest (ROI) of approximately 0.2 cm^2 were manually drawn within fibres of the frontal corona radiata (white matter), within the head of the caudate nucleus (grey matter) and extra-cranially (noise) (Figure 1a,b).

Results

Neither disturbing susceptibility artefacts nor flow artefacts were encountered in any sequence. Concerning grey levels, image contrast and detail resolution, the observers graded the tested 'Quiet 1' sequence as equivalent to the manufacturer's standard sequence and as superior to the other tested sequences. In the T_2w images, the observers could not differentiate the different sequences. In all cases, grey levels, image contrast and spatial resolution were evaluated to offer equally good diagnostic quality. The standard sequences had sound pressure level (SPL) values of 97 and 98 dB(A), respectively. The different tested quiet sequences had SPL values of between 23 and 32 dB less than the standard sequence, which corresponds to a subjective decrease of about between 93 to 97%. For the T_1w SE sequences the calculated contrast-to-noise ratios of the quiet sequences were significantly increased compared to the standard protocol. On the other hand, for the T_2w TSE sequences the contrast-to-noise ratio decreased with decreasing loudness.

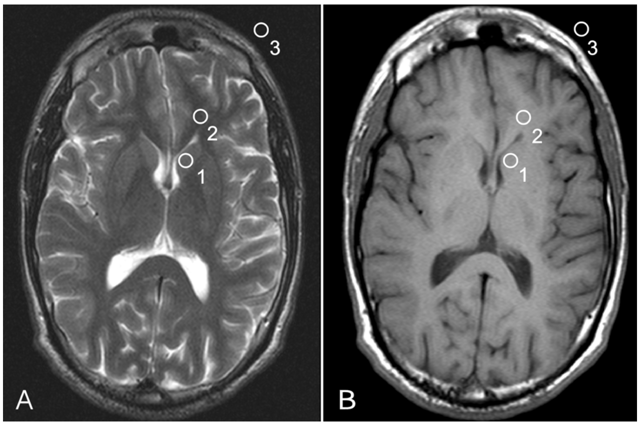

Fig 1.: T2w and T1w images with regions of interest.

Discussion

With the use of long sinusoidal gradient slopes for quiet sequences it was expected that a decrease in loudness would come along with an increase in scan time (4). However, we used a more effective way of inflow saturation to design a sequence with drastically reduced loudness and the same total scan time. The fastest quiet T_1w sequence (quiet 1) needs the same total measurement time as the loud standard protocol with a reduced sound pressure level of 74.5 dB(A) compared to 97.9 dB(A) for the loud standard. In this study we have shown that drastic reductions of noise levels are feasible in routine imaging tasks without any hardware modification. At the same time high image quality was maintained. However, further clinical trials have to be undertaken to validate the results of this volunteer study for diagnostic tasks.

References

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