BESA®

MRI 3.0

Recommendations for MRI Data in BESA MRI

Author(s):	Tobias Boldte, Andre Waelkens, Isabella Paul-Jordanov, Harald Bornfleth, Mateusz Rusiniak
Document name:	BESA MRI 3.0 - MRI Data Recommendations
Revision number:	001/06.2020
Revision date:	2020-06-10

Table of Contents

1. Introduction

BESA MRI offers a complete pipeline for pre-processing and segmenting magnetic resonance images (MRI). As an output the pipeline provides a scalp and cortex surface segmentation, as well as a volume conductor segmentation. The employed segmentation procedures were designed to be robust so that acceptable results are obtained also with suboptimal MRIs. Nevertheless, minimum requirements with respect to the quality of the MRIs exist, and better MRIs also facilitate a better segmentation.

This document will list the minimum and recommended requirements with respect to MRIs to be used in **BESA MRI**. MRI sequence parameters for T1- and T2-weighted images are listed in the next section. The following section discusses common MRI artifacts that shall be avoided, and gives further recommendations.

2. Recommended MRI Sequence Parameters

Recommended parameters are given for T1-weighted (Table 1) and T2-weighted MR images (Table 2). T1-weighted images are in any case necessary for the scalp, cortex, and volume conductor segmentation. T2-weighted images are optional, but can strongly enhance the accuracy of the volume conductor segmentation.

Sequence	3D spoiled turbo-gradient-echo sequence with inversion pre-pulse
Resolution	~ 1.0 x 1.0 x 1.0 mm³
Repetition / echo time	TR 9.2 ms / TE 4.4 ms
Flip angle	9°
Bandwidth	224.5 Hz/Px
# Acquisitions	2 (Averaging in frequency domain)
Inversion recovery time	1007 ms
Fat reduction	Selective water excitation
Description	This image sequence delivers T1 images with a good signal-to-noise ratio and a good gray-towhite matter contrast. The most remarkable characteristic of this image is the very efficient fat reduction. The good contrast between gray and white matter is necessary for an accurate cortex segmentation. Fat reduction is performed to avoid, that fatty tissue is shifted due to the chemical shift artifact and obstructs the inner or outer skull boundary.

Table 1: Sequence parameter recommendation for T1-weighted MRI.

Sequence	3D turbo-spin-echo sequence
Resolution	~ 1.0 x 1.0 x 1.0 mm³
Repetition / echo time	TR 2000 ms / TE 4.6 ms
Flip angle	Varies
Bandwidth	355 Hz/Px
# Acquisitions	1
Fat reduction	none
Description	This sequence delivers T2 weighted images with a good signal-to-noise ratio and a high, isotropic resolution. The water-fat-shift is adjusted to approximately one voxel. The high, isotropic resolution is especially important for the volume conductor segmentation. T2 weighted MR images with large inter-slice distances, which are quite common, are not suited for creating individual volume conductor models.

Table 2: Sequence parameter recommendation for T2-weighted MRI.

3. Further Recommendations

Several aspects influence the processing and segmentation of the MRIs in BESA MRI. The most important of these will be discussed here.

Image resolution: During the segmentation we have to differentiate structures which size is on the scale of sometimes only 1mm. The resolution of the MRI must be set accordingly. Ideally, the images are recorded at a resolution of 1.0x1.0x1.0mm³. Images with a high in-plane resolution but a large inter-slice distance are not suited for segmentation purposes.

Image noise: The approaches for scalp, cortex, and volume conductor segmentation in BESA MRI employ different kinds of regularization to reduce the influence of image noise on the segmentation accuracy. Still, when using MRIs with better signal-to-noise ratios better segmentation results will be obtained.

Field-of-view (FOV): The field-of-view determines the region that is visible in the MR recording. If the FOV is too small then the MRI might not contain any information about the subject's individual anatomy in some regions. BESA MRI will then not be able to segment the tissues in those regions. In order to obtain a good segmentation the FOV should include at least the complete head above a plane which is located approximately 40mm below the cranial skull (Lanfer et al., 2012). If the EEG is recorded with an electrode coverage that extends to even lower regions then the FOV should be extended accordingly.

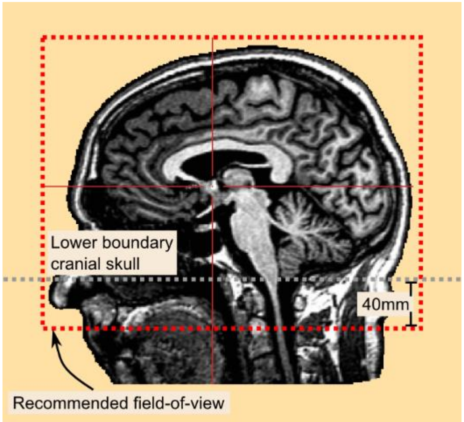

Figure 1 The recommended field-of-view.

Water-fat-shift artifact: The water-fat-shift artifact (or chemical shift artifact (Weinreb et al., 1985)) describes a phenomenon in MRI where the signal originating from protons embedded in lipid (fat) molecules is displayed at a location which is shifted relative to the signal originating from protons embedded in water. If an MRI is affected by this artifact you essentially see two overlaid images: a water image and a shifted fat image. In MRIs of the human head, for example, it might seem as if the subcutaneous tissue layer overlaps the outer skull boundary. From this example it is obvious that the artifact does have a severe influence on the volume conductor segmentation. To avoid problems MRIs should, thus, either be recorded with an effective fat suppression, or the bandwidth should be increased to minimize the water-fat-shift.

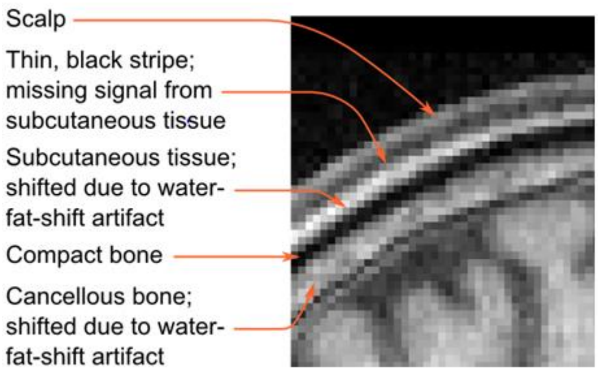

Figure 2 Illustration of the water-fat-shift artifact.

Motion artifacts: Movement of the subject inside the scanner during the MR measurement causes motion artifacts which manifest themselves as blurred image regions or ghost images (Bellon et al., 1986). The blurring and ghosting obscures the intricate head tissue boundaries and, thus, affects the segmentation accuracy. To avoid these artifacts the patient must not move inside of the scanner. A shorter acquisition time will decrease the c hance of the subject moving during the recording.

4. References

Bellon, E., Haacke, E., Coleman, P., Sacco, D., Steiger, D., & Gangarosa, R. (1986). MR artifacts: a review. Am. J. Roentgenol., 147(6), 1271–1281.

Lanfer, B., Scherg, M., Dannhauer, M., Knösche, T. R., Burger, M., & Wolters, C. H. (2012). Influences of skull segmentation inaccuracies on EEG source analysis. NeuroImage, 62(1), 418–431. doi:10.1016/j.neuroimage.2012.05.006

Weinreb, J. C., Brateman, L., Babcock, E. E., Maravilla, K. R., Cohen, J. M., & Horner, S. D. (1985). Chemical shift artifact in clinical magnetic resonance images at 0.35 T. AJR. American Journal of Roentgenology, 145(1), 183–185.