Remote detection by MRI at 3T using a waveguide

F. Vazquez[1], R. Martin[1], S. E. Solis[2], and A. O. Rodriguez[1]
[1]UAM Iztapalapa, DF, Mexico, Mexico, [2]Laboratorio de Neurofisiologia Integrativa, Instituto Nacional de Psiquiatria Ramon de la Fuente, DF, Mexico, Mexico

Introduction. The generation of magnetic resonance images with waveguides has been successfully demonstrated at 7 Tesla for whole-body systems. [1]. It has been previously shown published by our group that the waveguide approach can be used at 3T and whole-body systems using a parallel-plate waveguide [2]. The parallel-plate waveguide is probably the simplest waveguide available and its electromagnetic properties have been widely studied. The aim of this paper is to investigate the variation of the image intensity as a function of the separation between a coil and a phantom using a parallel-plate waveguide. In this work, a waveguide composed of only two parallel plates was used and phantom images were acquired.

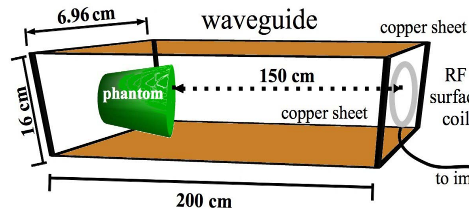

Figure 1. Experimental setup and an illustration of copper parallel-plate waveguide showing dimensions.

Material and Methods. To investigate the dimensions of the waveguide for the resonant frequency of the 3T system, the cut-off frequency of a parallel-plate waveguide was computed according to reference [2]. The f_{cutoff} is 116.20 MHz for the dominant mode TE1 at 120MHz, for a waveguide with a separation between the plates of 16 cm. A wooden structure was constructed to support two copper strips (16cm wide and 2000cm long) to build a parallel plate waveguide as shown in Fig. 1. RF transmission was performed with a whole-body birdcage (68 cm long, 66 cm diameter and 16 rungs), and reception was performed with a circular-shape coil array (12 cm diameter). The receive-only circular coil was positioned at one end of the waveguide opposite to the phantom: distance between them was varied and the image SNR was measured for each distance. Fig. 1 shows an illustration of the experimental setup. T2-weighted images of a saline solution phantom were acquired using gradient echo sequences with the following acquisition parameters: flip angle=20^0, TR/TE=336.9/16.1ms, FOV=450x190mm, matrix size= 500x169, slice thickness=10mm, NEX=10. All imaging experiments were carried out on a 3T clinical imager (Philips Medical Systems, Best, NL).

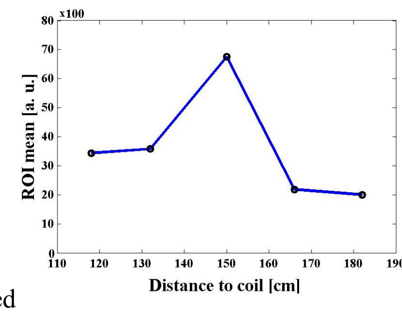

Figure 3. Plot showing variation of image intensity versus distance between coil and phantom.

Results and Discussion. The formalism of classical electromagnetic theory was used to determine the waveguide dimensions and properties to generate images. T2-weighted images of a saline solution phantom were acquired at different separations. Figure 2 shows some images at selected separations. From the image data, a region of interest (ROI) was chosen and its mean was calculated for all images. These means were plotted versus the separations between the coil and the phantom and are shown in Figure 3. From Figure 3 it can be appreciated that this waveguide is able to generate images at greater distances than the actual length of the magnet. The maximum value of the image intensity is reached at 150 cm separation. The wavelength of the resonant frequency of a 3T MR system (128.7 MHz for H1) is λ=2.3 m. These preliminary results may prove to be useful to develop waveguides for applications involving samples larger than the magnet length (167 cm), or alternatively to remotely generate images of objects located at a considerable distance from the coil or coil arrays. This methodology allows us to test a number of coil designs to study their performance and suitability for remote sensing MRI. We have experimentally demonstrated that the use of parallel-plate waveguides can produce images for remote sensing magnetic resonance imaging at lower magnetic fields than 3 Tesla with a clinical system and standard pulse sequences. We suspect that if the waveguide is operated with a transmit-only coil at one end, and a second receive-only coil on the opposite end, the image SNR will experience an improvement.

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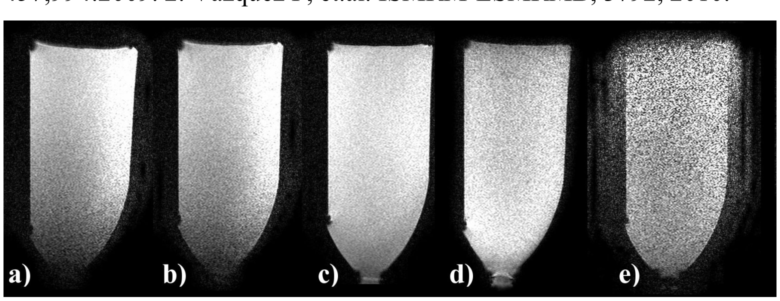

Figure 2. Phantom mages acquired at different separations:
a) 118 cm, b)132 cm, c) 150 cm, d) 166 cm, and e) 182 cm