

B1 homogeneity in breast MRI at 3T with dual-source radiofrequency transmission: An intraindividual comparison with 1.5T

Guillaume Gilbert^{1,2}, Isabelle Trop¹, Marko K. Ivancevic³, and Gilles Beaudoin¹

¹Department of Radiology, Centre Hospitalier de Montréal, Montreal, Quebec, Canada, ²MR Clinical Science, Philips Healthcare, Montreal, Quebec, Canada, ³MR Clinical Science, Philips Healthcare, Best, Netherlands

Target audience: Radiologists, engineers or physicists with an interest in breast imaging

Purpose

High field strength MRI remains challenging in many aspects. A well-known complication is the establishment of radiofrequency (RF) standing waves when a standard quadrature excitation is used, a phenomenon that can considerably reduce the transmit B1 homogeneity. For breast imaging, this B1 inhomogeneity manifests itself in the form of a left-right shading effect^{1,3}, with an impact on lesion enhancement ratios measured from dynamic contrast enhanced (DCE) acquisitions^{2,3}. A promising solution to the B1 inhomogeneity problems observed at 3T is the use of RF shimming. This approach uses multiple independent RF sources to optimize the transmit B1 field homogeneity. To our knowledge, the B1 homogeneity that can now be achieved through RF shimming using dual-source RF transmission at 3T for breast MRI has not been compared to that normally encountered at the clinical standard field strength of 1.5T. Meanwhile, reference B1 homogeneity values for breast MRI at 1.5T are not well established. Thus, the aim of this study was to evaluate and compare in a cohort of women undergoing both 1.5T and 3T breast MRI the B1 homogeneity achieved at 1.5 and 3T, and for both quadrature and dual-source transmission at 3T.

Methods

This prospective study received institutional review board approval and all subjects signed an informed consent form. 25 women (mean age 53 years old; range 30-69) with suspected breast lesions underwent breast MRI exams on 1.5T and 3T clinical systems from the same manufacturer, using equivalent 16-channel dedicated breast coils. B1 maps were obtained using a 3D actual flip angle (AFI) acquisition, at 1.5T and at 3T with both quadrature and dual-source radiofrequency transmission. Each breast was manually segmented and the whole breast mean B1 and standard deviation of B1 were evaluated. B1 values were expressed as a percentage of the requested value. Differences in mean B1 and standard deviation of B1 between right and left breasts were compared using a two-sided multivariate analysis of variance, including a Tukey correction for multiple comparisons, while differences between measured whole breast mean B1 and requested B1 were investigated using t-tests.

Results and Discussion

Whole breast mean B1 and standard deviation of B1 are presented in Table 1. With quadrature transmission, a significant left-right shading is observed at both 1.5T and 3T, with mean B1 values systematically lower than the requested value on the left ($p < 0.001$ at 1.5T and 3T) and higher than the requested value on the right ($p < 0.001$ at 1.5T and $p = 0.01$ at 3T). Although the average left-right B1 shading effect is of the same scale at both field strengths with quadrature transmission ($-14.3\% \pm 3.1$ at 1.5T and $-16.4\% \pm 4.6$ at 3T), overall B1 homogeneity is appreciably worse at 3T as reflected through the higher standard deviation values for 3T with quadrature transmission. In comparison, the mean B1 and standard deviation of B1 values for each breast are not statistically different when dual-source RF transmission is used at 3T and are not statistically different from the requested B1 value ($p = 0.34$ for the left breast, $p = 0.29$ for the right breast), showing high B1 accuracy.

The left-right B1 shading observed at both 1.5T and 3T with quadrature transmission can be further assessed from the cumulative distribution curves presented by Figure 1 (a and b). It can be observed that a substantially higher B1 homogeneity is achieved for the right breast in comparison to the left. In contrast, a very similar behaviour is observed for both breasts at 3T with dual-source RF transmission (Figure 1c). Figure 1d additionally presents the overall B1 homogeneity by considering both breasts together as a single region-of-interest. The best overall B1 homogeneity is achieved at 3T with dual-source transmission, followed by 1.5T; 3T with quadrature RF transmission offers the worst performance.

Conclusion

3T MRI with dual-source radiofrequency transmission offers an overall B1 homogeneity for breast imaging that is better than that obtained at 1.5T and at 3T with quadrature transmission.

References

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Figure 1 : Cumulative distribution curves for a) Right and left breasts separately at 1.5T. b) Right and left breasts separately at 3T with quadrature transmission. c) Right and left breasts separately at 3T with dual-source transmission. d) Both breasts together at 1.5T, 3T with quadrature transmission and 3T with dual-source transmission. Dotted lines curves display the 95% confidence interval as estimated from a bootstrap analysis with 1000 resamples.

	Left breast		Right breast		Left-right shading	p value	
	Mean B1	Std B1	Mean B1	Std B1		Mean B1	Std B1
1.5T with quadrature transmission	91.1 ± 2.2	6.5 ± 1.4	105.4 ± 2.6	3.9 ± 0.7	-14.3 ± 3.1	< 0.001	<0.001
3T with quadrature transmission	86.3 ± 3.1	9.3 ± 2.1	102.7 ± 4.7	7.6 ± 2.4	-16.4 ± 4.6	< 0.001	0.03
3T with dual-source parallel transmission	99.4 ± 3.3	7.5 ± 2.4	99.3 ± 3.2	7.3 ± 1.9	0.1 ± 2.8	1.0	0.99

Table 1 : Whole breast B1 values.

