The Effects of Breast Radiographic Markers on MRI and MRS: *Ex Vivo* Testing of Artifacts at High Magnetic Field (4 Tesla)

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Purpose: There has been a recent trend towards the use of Breast Radiographic Markers (RM), also known as tissue marker clips. Breast RM are used for a variety of applications, such as marking the site of a needle breast biopsy for surgical planning or identifying the location of a breast lesion for follow up (1-4). With recent technological advances in MR imaging (MRI) with spectroscopy (MRS) for the diagnosis and management of breast cancer, careful consideration must be taken into how RM affect breast MRI and MRS. There has been one previous report which evaluated the imaging artifact of a breast RM at 1.5T (5). To the best of our knowledge, there have been no published reports evaluating the effects of breast RM on MRI and MRS at higher fields. For this reason, we evaluated 6 FDA-approved breast RM, which were originally designed for visibility under mammography and ultrasound, from 5 manufacturers and compared the MRI and MRS artifacts each produced at 4 Tesla.

Materials and Methods: Six FDA approved breast RM, 4 stainless steel alloy, 1 titanium alloy, and 1 pyrolytic carbon coated zirconium oxide (CZO), each measuring 3mm in longest diameter, were individually placed in separate gelatin phantoms. Each RM was representative of the manufactured finished version of the product and was not altered in any manner. All measurements were performed on a whole-body research 4T scanner (Varian *Unity Inova* console, Siemens *Sonata* gradients, Oxford *4T-900* magnet). A single-breast quadrature transmit/receive RF surface coil was used to study each RM phantom. The spatial extent of the MRI artifact was measured using a 3D FLASH image (TE/TR = 4/17ms, FA=30 degrees, 0.4 x 0.4 x 1.7 mm resolution). Spectroscopy was performed by measuring the linewidth of the water resonance from a 1 mL voxel centered on each RM and the water linewidth measured in a control voxel containing no RM. The spectral artifact was calculated by taking the difference between the linewidth measured from the voxel on the RM and the control voxel. Manual adjustment of the linear shims was performed on all voxels.

Results: A summary of the imaging and spectral artifacts are shown in Table 1. *Imaging artifact*: All 6 RM clearly produced a void artifact in the gelatin phantoms (figure 1). Imaging artifacts produced by the stainless steel alloy RM varied from 8-18 mm, while the titanium alloy RM showed a 6 mm imaging artifact. The CZO RM showed the least amount of imaging artifact (3 mm). *Spectral Artifact*: All 6 RM created B_0 inhomogeneities which produced spectral distortion. The control voxel had a linewidth of 0.044 ppm. Water linewidths in the stainless steel RM voxels ranged from 0.080-0.567 ppm. The titanium alloy and CZO RM voxel had a linewidth of 0.740 and 0.067 ppm, respectively. The CZO RM showed the least amount of spectral artifact (0.023 ppm).

Conclusion: Based on our results, breast MRS may not be performed on lesions which contain the stainless steel RMs evaluated in this study. However, the CZO and titanium RM produced the least amount of imaging and spectral artifact and therefore would be most preferable for use in subjects who will be followed with high-field MRI and MRS scans. It is important to note that all 6 RMs were 3mm in size. However, they produced different imaging and spectral artifact which is most likely due to their composition and geometric shape. It is important to note that each RM produced a void artifact and thus visualization of the RM may be hindered if placed within fatty tissue rather than the enhancing lesion. Further testing and development is necessary to identify RMs which are MR visible but produce minimal artifacts and do not interfere with spectroscopy.

Table 1

	Radiographic Marker (Model)	Material	Imaging Artifact (mm)	Spectral Linewidth (ppm)	Spectral Artifact (ppm)
1	InRad (REF871017)	Stainless Steel Alloy	18	0.567	0.523
2	Mammotome (REFC1535)	Stainless Steel Alloy	9	0.102	0.058
3	SenoRx MK (MK0016)	Stainless Steel Alloy	9	0.087	0.043
4	SenoRx GM (GMUTC005)	Stainless Steel Alloy	8	0.080	0.036
5	Artemis (CAT #31-01)	Titanium Alloy	6	0.074	0.030
6	BiomarC (#040101)	Carbon Zirconium Oxide	3	0.067	0.023
7	Control		0	0.044	0

References:
(1) Smathers RL. Am J Roentgenol 2003 Feb; 180(2):355-6.
(2) Baron LF. Am J Roentgenol 2000 Feb; 174(2):539-40.
(3) Dash N. AJR Am J Roentgenol 1999 Oct; 173(4):911-7.
(4) Krawczyk JJ. Int J Radiat Oncol Biol Phys 1999 Jan 15; 43(2):347-5
(5) Shellock FG. AJR Am J Roentgenol 1999 May; 172(5):1417-9.

Figure 1: Phantoms representing each radiographic marker