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Meeting abstract

Intraductal micro magnetic resonance imaging and spectroscopy

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The majority of breast cancers originate in the mammary ducts. As such many diagnostic techniques introduce mm-diameter devices into the ducts through the nipple. Established intraductal techniques include ductal lavage, and white-light or fluorescence endoscopy. While reported values vary, these techniques typically suffer from low sensitivity and specificity. Similarly, Magnetic Resonance Imaging (MRI) for breast oncology suffers a high rate of false positives. Magnetic resonance (MR) spectroscopy is highly effective in distinguishing between benign and malignant tissue. However, clinical relevance is limited to late-stage of disease due to a required cubic-centimeter volume for diagnosis. Small-volume sensitivity for spectroscopy and imaging is possible through use of a miniature radio-frequency (RF) coil. An intraductal RF microcoil reduces the required volume of diseased tissue to a cubic-millimeter, bringing spectroscopy to early stages of early diagnosis. Micro-scale images from an intraductal microcoil may enable high-precision localization of tumors and tumor margins. The microcoil catheter was designed with an approximate diameter of 1 mm for intraductal use and for possible integration with ductoscopes. Experimental verification of the first-generation coil-design was achieved through *ex vivo* MR imaging of tissue. As expected, the microcoil provided microscale images. While 3-T (128 MHz) MRI typically provides 1 to 30 voxels per-cubic-mm the MRI microcoil can provide hundreds, and even thousands of voxels in the same volume. The first generation microcoil consisted of a 1-mm-diameter solenoid with 4.5 turns, spaced 0.05 mm apart, leading to 25-mm long parallel leads, with one of the leads passing through the center of the solenoid. A crucial requirement for optimal MR coil design is a homogenous magnetic field generated in the coil. Unfortunately, the central conductor inside the solenoid of the original microcoil greatly disturbed the homogeneity of the magnetic-field. The parallel-leads of the first generation device correspond to a popular catheter-coil geometry, a single-loop coil. The parallel leads therefore collect unwanted signal, in other words noise. The new design overcomes both of these flaws. Turn-spacing of the first microcoil design was intended for optimizing the signal collected from the center of the solenoid. However, since the target tissue is at the tip of the solenoid, the new design is optimized for our target tissue with ten turns separated by the thin insulation of the wire. The turn-spacing of the first generation microcoil was controlled by a thick layer of insulation that also provided a good barrier from the body. Due to the lack of a thick insulator, the second generation-design required a new configuration for isolating the coil from the body to prevent degradation of the performance over time. We analyzed the stability of the new microcoils by soaking 5 microcoils in body temperature saline and measuring the impedance at 128 MHz over time. The impedance of the microcoils remained constant for nearly 2 hours, and increased only slightly after 4 hours. Preliminary heating experiments indicate that little to no heating occurs during use of the microcoil as an MR transceiver. Initial imaging results confirm that the second generation microcoil improves greatly on the first genera-

tion coils, with significantly less imaging artifacts despite having twice the lead length.

Recent success by Dr. Love with intraductal chemotherapy application intensifies the need for early diagnosis. A microcoil may provide spectroscopic evidence of cancer. Microcoil images may show if the malignancy has breached the ductal lining. The open lumen of the intraductal microcoil enables clinicians to target sub-branches of ducts with chemotherapy.