Flexible Miniaturized Antennas for Minimally Invasive Microwave Ablation

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Microwave ablation (MWA) is a promising therapeutic technique for treating diseases such as liver cancer (M. G. Lubner, et al., Semin. Intervent. Radiol., 30, 56-66, 2013) or lung cancer (L. Sidoff and D. E. Dupuy, Int. J. Hyperthermia, 33, 25-33, 2017). In this technique, a minimally invasive interstitial antenna delivers electromagnetic energy to the tumor. The deposited electromagnetic energy heats the tumor to cytotoxic temperatures, causing protein denaturation and cell necrosis. Current MWA applicators employ rigid coaxial cables as their feed lines and are typically inserted percutaneously. This, however, increases the invasiveness of ablating tumors that are deep inside the body. If the rigid antenna is replaced by a flexible one, such tumors may be accessed less invasively via natural ductal or vascular pathways.

Recently, we proposed and demonstrated a balun-free dipole antenna that generates localized, nearly spherical ablation zones without an internal impedance matching network (Y. Mohtashami, et al., USNC-URSI National Radio Science Meeting, Boulder, Colorado, 2018). The outer conductor of the coaxial cable is extended to form a helix that encompasses the extended inner conductor. These two extensions form two arms of a dipole antenna. Unwanted current on the outer surface of the outer conductor is effectively choked due to the relatively low feed point impedance of this antenna. This choking results in a compact specific absorption rate (SAR) pattern. The balun-free dipole antenna used in our pilot studies was fabricated with a rigid 2.38-mm-diameter coaxial cable for operation in egg white.

We build upon this recently proposed balun-free antenna and design a flexible miniaturized version for a next-generation MWA system. We implement the feeding cable of the antenna using a flexible narrow-diameter coaxial cable and create the helical outer conductor extension using a compression spring. We then test the maneuverability and curvature limits of the fabricated flexible prototypes by routing them through flexible catheters. Further, we characterize the performance of the fabricated flexible antennas through *ex vivo* ablation experiments and test the degree of the reproducibility of the results. Our investigations to date suggest that the proposed flexible antenna shows promise for minimally invasive thermoablative treatment of diseased tissue that can be reached through intravascular or intraductal pathways.