A Balun-Free Hybrid Helix/Monopole Antenna for Microwave Ablation

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Microwave ablation (MWA), a promising technology for cancer treatment, uses an interstitial antenna to deliver microwave power to tumors. The deposited electromagnetic energy heats the tumor to cytotoxic temperatures resulting in nearly instantaneous cell death. A MWA antenna is expected to have a small overall diameter, a low reflection coefficient, and localized specific absorption rate (SAR) and heating patterns. Most MWA antennas employ coaxial cables as their feed lines. Unbalanced current in these antennas is effectively suppressed by equipping the coaxial cables with baluns. While balun-equipped designs produce fairly localized ablation zones, they increase the overall diameter and hence, invasiveness of MWA antennas.

Several techniques have been employed to reduce the overall diameter of MWA antennas. A recently proposed balun-free base-fed monopole antenna (H. Luyen, et al., IEEE Trans. Antennas Propag., 63, 959-965, 2015) achieves localized ablation zones when operated at the second resonant frequency; however, this design requires an internal impedance matching network. Another recent example is a coax-fed antenna with a tapered slot-balun wherein the outer conductor is gradually tapered toward the distal end and formed into two dipole arms (H. Luyen, et al., IEEE Trans. Antennas Propag., in press, 2017). This design, however, has a relatively long radiating section and therefore is more suitable for operation at higher frequencies.

In this paper, we present a balun-free hybrid helix/monopole antenna for producing localized ablation zones. In this design, a helical outer conductor encompasses a monopole antenna created from the inner conductor of the coaxial cable. This helix, which acts as a base-fed monopole, is exploited at its third resonance. At the feed point of the antenna, both the helix's current and the current flowing on the inner surface of the outer conductor of the feeding cable have a maximum. Both currents also flow in the same direction at the antenna's feed point. This continuity effectively suppresses currents that tend to get excited on the outer surface of the outer conductor. The fields produced by the currents flowing on the monopole and the helix destructively interfere closer to the feed point, while constructively interfering further from it. This helps the antenna produce an almost spherical ablation zone. Measurement results of a fabricated prototype of the antenna were consistent with the simulations and confirmed the capability of the antenna in generating localized ablation zones. Our proposed design can serve as a promising candidate for performing minimally invasive ablation therapy within flexible and maneuverable embodiments.