Abstract

Iman Galal Mahumod Ibrahim

A study of microwave TDFT applicator design for low power cancer ablation

The development of therapeutic thermal ablative techniques become viable alternative method to treat patients who cannot be treated by surgery because of high surgical risk unfavourable tumour location. Microwave ablation is the least invasive technique recently developed for cancer treatment because of its low cost, smaller antenna size and shorter recovery time. However, there are shortcomings of microwave ablation therapy needed to be fulfilled. Unsuccessfully ablated tumour and destruction of large portion of surrounding healthy tissues due to usage of exceptionally high input power which yields lack of control over heating encountered with previously proposed applicator designs. This work investigates the efficacy of using low power ultra-wide band (UWB) microwave applicator in cancer ablation. A novel Tear Flared tipped (TDFT) antenna was proposed as microwave applicator for treating focal malignant tumours using low input power by the means of directed axial radiation. TDFT antenna is modelled and analysed in different surroundings such as saline, healthy and malignant tissue models. Semi-analytical numerical model is introduced to calculate current distributions required on antenna and consequent near-field distribution for achieving homogenous heating conformal to the targeted lesion to overcome nonuniform field distribution of omni-directional radiation. Electromagnetic simulations showed that TDFT antenna achieved minimum reflection stability of -25.89 dB over ultra-wide bandwidth. Electromagnetic and thermal simulations proved that directed axial radiation within targeted lesion produce confined uniform heating at significantly low input power. Moreover, 60 ? temperatures were attained for successful ablation and provided more control over heating within the targeted lesion. Highest SAR value attained of 967.3 W/kg for only 3W input power. Thermal analysis revealed that TDFT antenna can achieve a successful ablation of spherical cancerous lesions of diameters of 15.5 mm in 3 minutes for input power of 3W. TDFT antenna was fabricated and tested in egg-white solution and bovine liver. A good agreement between the measured and simulated results were observed where overall efficiency of 99.99% was recorded at the operating frequency. Ablation experiments were conducted in egg-white solution and bovine liver for 1W input power. Feasibility of TDFT antenna as a microwave coagulator was clearly observed in creating confined heating manifested in ablated lesions of 16×19.5×19.5 mm3 for 15-min ablation. Highly-directed End-fire radiation of TDFT antenna noticeably achieves confined heating that facilitates using only 60% of the lowest input power recorded in literature to attain successful ablation in standard radiation exposure time of 15 mins. This reduces power consumption of microwave applicator by almost 40% of the lowest input power used in literature.