DESIGN AND SIMULATION OF WATER-COOLED ANTENNA FOR MICROWAVE TUMOUR ABLATION

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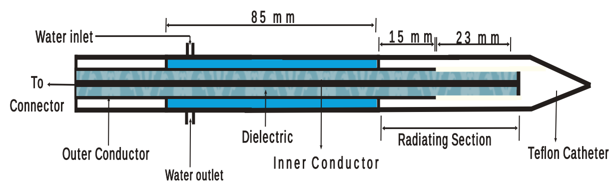
Abstract— **Background**: Microwave ablation is a modern technique for treating cancerous tissues with the controlled application of heat. Some tumours are located in such a way that they cannot be successfully treated with conventional external radiation beam techniques. Microwave ablation is currently an alternative option being considered for the treatment of unresectable tumours. The aim of this study is to develop a water-cooled antenna that is able to remove the unwanted heat generated along the shaft of the antenna**. Methods**: Single slot, dual slot and monopole antennae were designed and compared with the newly designed water-cooled antenna (Figure 1). All the antennae were designed and simulated using Finite Element Method (FEM). For the open loop design, the water slot position, water slot length and the antenna slot length from the tip of the antennae were varied within the ranges $43 \leq z \leq 60$ mm, $1 \leq z \leq 10.5$ mm and $1 \leq z \leq 20$ mm at 1 mm, 0.5 mm and 0.5 mm intervals respectively. For the closed loop design the model was simulated at multiple discrete lengths of slots between 2.5 mm and 4.5 mm, using 0.1mm increments to determine the slot height. A ring-shaped slot 5.8 mm diameter was made from the outer conductor, 4mm in length from the tip. The slot position was varied between 4 and 30 mm from the radiating tip of the antenna. The most optimized antenna was constructed from 0.085′ RG-405/U semi rigid coaxial cable to match the prototype geometries in the simulation procedures. A solid-state microwave generator was used to produce 2.45 GHz frequency. A Syringe Pump (stackable syringe pump JZB – 1800c) was used to introduce cooling water into the pipe inserted along the shaft of the external conductor of the antenna. Bovine liver, muscle, lung, heart and breast samples purchased from a local government abattoir were ablated using input powers of 30, 50, 80 and 120 W for 5 and 10 min.

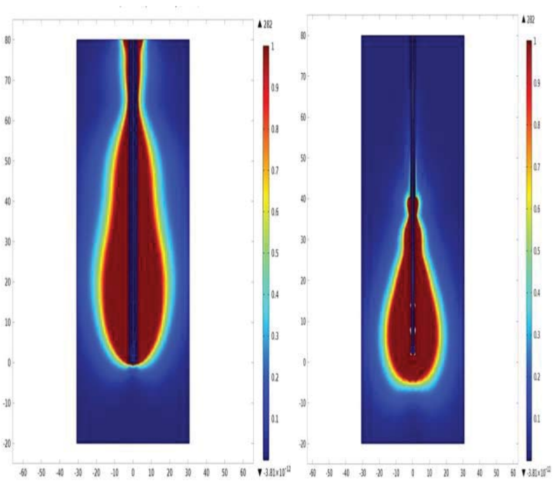
Results: From the simulation results (Figure 2), the best optimized design produced reflection coefficient -25.5dB, ablation length of 48.5 mm, ablation diameter 40.1 mm with 94 % power dissipation into the tissue. There were no significant difference in the simulation and the experimental results of the water-cooled antenna. In this study, water-cooled antenna of low reflection coefficient has been developed for microwave ablation of different tissues.

Conclusion: The study demonstrated that the inclusion of the cooling unit is capable of reducing backward heating along the shaft of the antenna (Figure 3). This study has demonstrated that microwave ablation using a cooling unit can be applied as one of the treatment modalities in the management of localized tumours.

Keywords — Cancer, Microwave Ablation, Tumour, Water-cooled, Antennae.

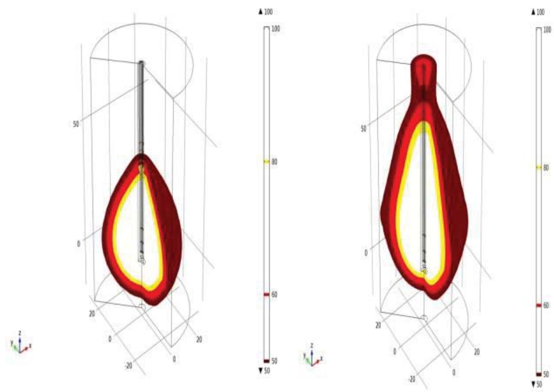


A. Figure 1: Radiating section of the monopole water-cooled antenna.



(a.) (b.)

Figure 27: Distribution of power dissipation density in tissue for closed loop antenna (a) without cooling unit (b) with cooling unit for 60 W 600 s.



(a.) (b.)

B. *Figure 3: Three dimensional view of the ablated region at 120 W 600 s. (a) with cooling and (b) without cooling unit.*