

3-D VERSUS 2-D STEERING IN PATIENT ANATOMIES: A COMPARISON USING HYPERTHERMIA TREATMENT PLANNING.

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Introduction: The AMC-8 70 MHz phased-array waveguide system is an eight channel regional hyperthermia device consisting of two rings with each four waveguides. This system enables 3-D steering, where the single ring version of the system, the AMC-4 system, is capable of 2-D steering only. This 3-D steering is expected to result in improved regional hyperthermia treatment.

Purpose: A comparison was made between the performance of the AMC-4 and AMC-8 system based on tumour temperature and the occurrence of hot-spots for patients with a cervical carcinoma using hyperthermia treatment planning.

Methods: For five patients with a cervical carcinoma a CT-scan has been made in treatment position. After manual segmentation of the tumour, the anatomy was segmented into fat, bone, muscle tissue and inner air based on the Hounsfield units. Tissue properties were assigned using values from literature. Using a finite-difference-time-domain method, the electric fields induced by the individual antennas were calculated. The calculated electric fields were then used as input for a temperature-based optimisation procedure based on Pennes' bioheat transfer equation. The objective of the optimisation procedure was to minimise the tumour volume with a temperature lower than 43 °C using a maximum temperature of 45 °C for the normal tissue as a constraint. This procedure was repeated for the AMC-8 system using different values for the ring distance (1, 3, 5, 7 cm).

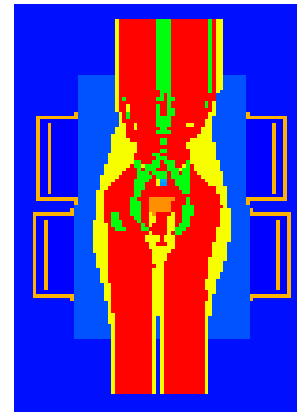


Figure 1: An example of a geometry used for FDTD calculations.

Results: With large inter-patient variability, an increase in tumour temperature of 0.5 °C was typically predicted when using the AMC-8 system instead of the AMC-4 system. To obtain this result, doubling of the delivered amount of power was typically required. Variation of the ring distance can influence the achieved tumour temperature, but the dependency between tumour temperature and ring distance varies from patient to patient. Hot-spots are commonly found to be located at the same anatomical position when comparing both systems. At the right and/or left flank of the patient, in the region between the two rings, hot-spots were predicted in all five patient cases when using the AMC-8 system.

Conclusion: From these simulations it can be concluded that application of the AMC-8 system will lead to a clinically relevant increase in tumour temperature.