The potential of time-multiplexed steering by temperature optimization in microwave hyperthermia

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The potential of time-multiplexed steering by temperature optimization in microwave hyperthermia

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Introduction: In clinical practice at Erasmus MC, the target-to-hotspot-quotient (THQ) of the specific absorption rate (SAR) is used to optimize phases and amplitudes of the signals to be applied to the hyperthermia applicator [1]. Recent research showed that the ratio between tumor and healthy tissue temperatures can be increased when amplitudes and phases are time-multiplexed when applying SAR optimization [2]. However, direct temperature optimization achieves higher tumor temperatures when considering time-multiplexed antenna steering [3]. In this work, we investigated the benefit of time-multiplexed steering when applying temperature optimization in models of patients with tumors on the head and neck region.

Methods: For five patients with a tumor in the head and neck region, a Sim4Life model was created and treatment planning was applied for the HyperCollar3D. A single distribution SAR based THQ optimization was performed for reference. A novel temperature optimization scheme was developed, which optimizes the tumor temperature for the first 15 minutes of the treatment. This results in higher tumor temperatures throughout the treatment by explicitly including the transient effects in the optimization. The evaluation was based on simulations of the full treatment time of 75 minutes, with the total power scaled to reach maximum 43°*C in the tumor*. Performance was evaluated by comparing T50 for both healthy and tumor tissue during treatment.

Results: The ratio between T50 in the healthy and tumor tissue was improved when using the novel temperature-based optimization for time-multiplexed distributions (Figure 1C). The SAR THQ showed a lower ratio for the time-multiplexed solution, this is resolved in the temperature simulations (Figure 2).

Discussion: The resulting T50 values, show that the temperatures during treatment might benefit from the temperature optimized with the multiplexed steering approach: either the temperature in the tumor tissue can be higher or the temperature in healthy tissue could remain lower. Although the approach seems beneficial, assessment of the impact of uncertainties in thermal parameters and inclusion of a larger dataset is still required to assess the significance of the improvement and the expected clinical benefit [4].

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