

SAR MEASUREMENTS AND FDTD CALCULATIONS IN TISSUE-EQUIVALENT PHANTOMS FOR DIFFERENT TYPES OF CFMA-434 APPLICATORS FOR SUPERFICIAL HYPERTHERMIA.

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Introduction

Contact Flexible Microstrip Applicators (CFMAs) have an operating frequency of 434 MHz and are applied for superficial hyperthermia in e.g. melanoma and chest wall recurrences. The applied bolus thickness and the effective field size are important parameters for clinical application. Temperature information during clinical hyperthermia is limited, since invasive measurements are limited to avoid implant risks for the patient. Therefore, hyperthermia treatment planning is very useful to analyse the behaviour of CFMAs in different clinical setups (patient anatomies).

Aim: The first step in applying treatment planning is to compare simulated and measured SAR distributions for different types of CFMAs in tissue-equivalent phantoms.

Methods

Measurements: Measurements were performed using a flat rectangular muscle-equivalent phantom ($\sigma=1.2 \text{ S m}^{-1}$, $\epsilon_r=77$) and a rectangular muscle-equivalent phantom with a superficial fat-equivalent layer ($\sigma=0.04 \text{ S m}^{-1}$, $\epsilon_r=5.5$) of 1 cm. A thermocouple sheet at 1 cm depth was used to measure the SAR distribution by applying a power pulse technique. Various applicator sizes were examined, with a bolus thickness varying from 0.5 to 2 cm. The active radiating electrodes of the applicator had a rectangular shape of $7 \times 20 \text{ cm}^2$, $16 \times 15 \text{ cm}^2$, $29 \times 21 \text{ cm}^2$, $21 \times 20 \text{ cm}^2$ or $20 \times 29 \text{ cm}^2$. The measurement accuracy is approximately 10%.

Simulations: Simulations were performed using our FDTD-based treatment planning system at a resolution of $x \times y \times z = 2 \times 2 \times 1 \text{ mm}^3$. The z -axis was modelled perpendicular to the electrode plates of the applicator. The computational domain was truncated using a perfectly matched layer absorbing boundary condition, which absorbs the electromagnetic waves as if the domain was not truncated.

Analysis: Measured and simulated SAR values were normalised. The maximum value was assigned 100%. The measured effective field size at 1 cm depth, i.e. the area contained by the 50% SAR contour, was determined and compared with the simulations. Furthermore, contour plots of the measured and simulated SAR at 1 cm depth were created and compared.

Results

A good correspondence was found between measurements and simulations. The effective field size in the fat-muscle phantom ranges between $\sim 60 \text{ cm}^2$ and $\sim 300 \text{ cm}^2$, depending on the sizes of the antenna. Both measurements and simulations showed a split-up of the SAR focus when a large bolus thickness ($\sim 2 \text{ cm}$) was used. Differences between measured and calculated SAR were less than 10%.

Conclusion

CFMA-434 applicators for superficial hyperthermia can be modelled with an acceptable accuracy.