DOSIMETRY OF RAT-HEAD SAR CAUSED BY A HIGH-PERFORMANCE "8"-SHAPED APPLICATOR

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Abstract

An 8-shaped loop applicator has been developed in order to observe reversible biological effects of localized exposure to microwaves from a cellular telephone. The applicator has been constructed with two resonant loops. Numerical dosimetry has demonstrated that the applicator is excellent in locality and homogeneity with numerical computation. Experimental dosimetry has also been performed in order to validate numerical dosimetry. The measured SAR values agreed with the calculated values.

1. Introduction

There have been great concerns of the general public about the possible health effects of exposure to microwaves (MWs) from cellular telephones. To investigate unknown biological effects caused by cellular phones, MW energy absorption should be focused within the head region of laboratory animals. Several *in vivo* studies using local exposure set up have been reported [1, 2]. In those experiments, biological effects were observed after MW exposure followed by scarification of the exposed animals. Previous studies may have, thus, overlooked possible effects which appear only during MW exposure. We have therefore proposed a new exposure system [3] that allows us to simultaneously observe biological effects on rat brains during MW exposure.

In this presentation, we demonstrate numerical dosimetry in order to optimize the design of the exposure system as well as experimental dosimetry for validation of the numerical dosimetry. The homogeneity of the SAR distribution within the target region is also evaluated because it is one of important parameters required for the exposure system.

2. Rationale of Applicator Used in Exposure System

The developed applicator is based on the 8-shaped coil for the magnetic stimulus of cranial nerves [4]. The near field of the 8-shaped loop applicator is strengthened at the center by electric current in phase. While the 8-shaped coil is electrically small loop, the developed applicator consists of two resonant loops in order to improve the mismatch between the applicator and the feeding line. In order to improve the localization of the SAR distribution, we optimized the shape of the loop by using numerical dosimetry described in following sections. The schematic of the optimized 8-shaped loop applicator is shown in Fig.1.

The 8-shaped loop applicator has two aperture in the substrate. Applying this applicator to

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“cranial-window rat [5]” as shown in Fig.2, real-time observation can be realized.

3. Dosimetry

3.1 Models and Methods

The SAR in the rat exposed to the 8-shaped applicator was evaluated numerically and experimentally. Finite-difference time-domain (FDTD) simulation with realistic inhomogeneous rat models can calculate detailed SAR distribution in the rats although some artifacts possibly appear around complex structures like the applicator and strong electromagnetic coupling between the applicator and the rat. Experimental SAR measurement using homogeneous rat phantoms and a thermography was therefore performed in order to validate the numerical simulation. The Rat numerical model (8 tissue types + Cranial Window, 1mm resolution) and the rat phantom with the same shape as the numerical model are shown in Fig.3.

The calculation condition of numerical dosimetry is that the cell size of FDTD method set up the analysis domain with 161*161*231 as 1mm cube. The developed applicator was excited at the frequency of 1.5GHz FDTD simulation, and simulation time was 60 periods (46200 time steps).

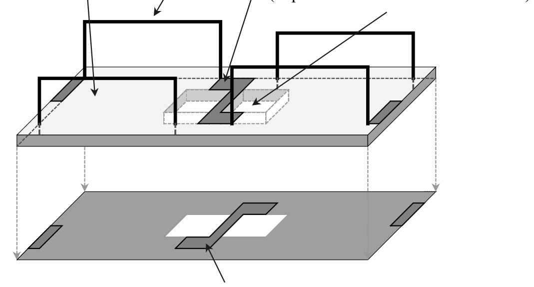

Figure 1: Overview of the 8-shaped loop applicators.

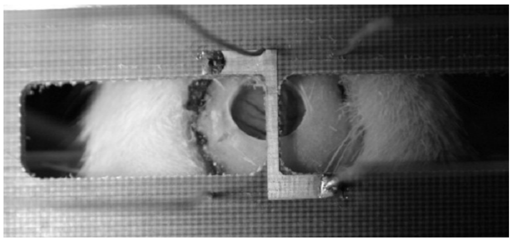

Figure 2: Cranial-window rat and developed applicator.

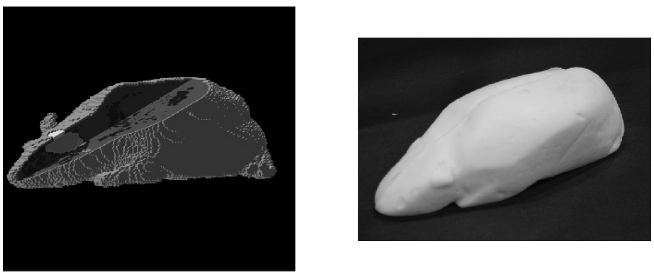

Figure 3: Inhomogeneous voxel rat model (left) and homogeneous rat phantom (right).

3.2 Results and Discussion

3.2.1 Return loss of the 8-shaped loop applicator

Calculated and measured values of return loss (S11) of the applicator are shown in Fig.4. Good agreement is obtained around the target frequency (1.439GHz). It is also shown that the return loss hardly changes in regardless with the existence of the rat. From these results, we concluded that the variation due to the rat movement results in at most 25% in SAR value.

3.2.2 SAR distribution in rat head

The calculated SAR distributions of the numerical rat model are shown in Fig.5. It is shown that high SAR has locally appeared on the brain surface or under the cranial window.

Homogeneity in the SAR distribution within the target area, i.e., upper surface of the brain tissue under the cranial window is evaluated with the SAR histogram in the target region (Fig.6 (b)). The SAR histogram of the previously developed small loop applicator [2] is also shown for comparison. The SAR caused by the two applicators are low values in most region of the brain tissue, while high SAR focuses in small region of the brain (Fig.6 (a)).

The SAR localization within the target tissue is better by the small loop applicator than by the developed applicator. The developed applicator can however achieve to enough localization of SAR within the target tissue (the ratio of the averaged SAR within the target tissue to that within the whole body is 80). The homogeneity is, on the other hands, better by the developed applicator than by the small-loop applicator. The developed applicator can therefore realize both requirements, i.e., homogeneity and localization of the SAR distribution within the target tissue.

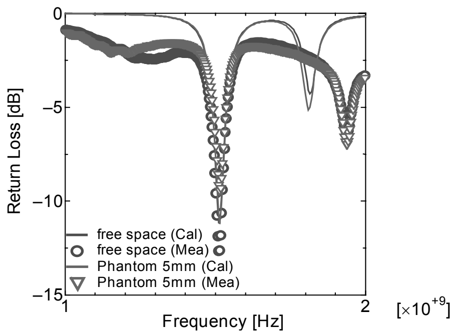

Figure 4: Frequency characteristics of the return loss of the 8-shaped loop applicator.

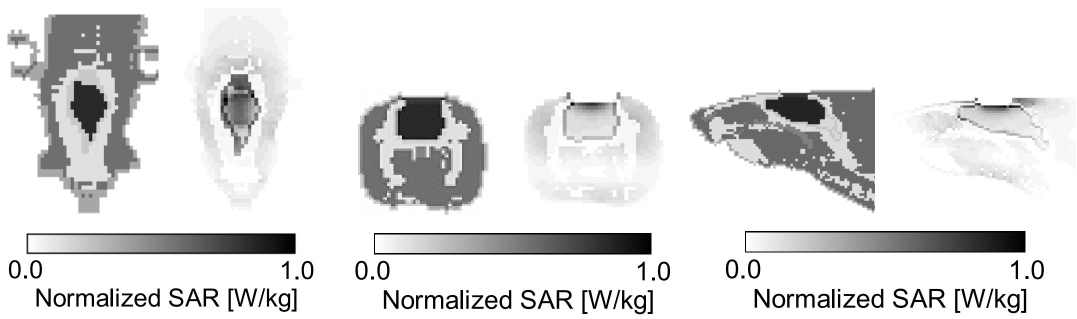

Figure 5: Calculated SAR distributions on the top surface of the brain (left), in the mid section of the brain normal to the sagittal axis (center), and in the sagittal section (right).

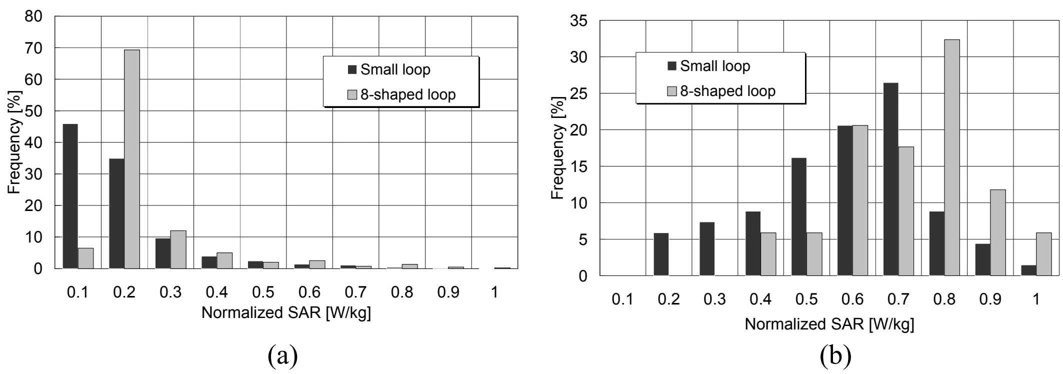

Figure 6: SAR histogram of in the Cranial-Window rat brain (left). SAR histogram of the target tissue, i.e., brain surface right under the cranial window.

3.2.3 Comparison between calculation and experiment

The experimental dosimetry was performed with the thermostat camera (Avionics co., LTD, Thermal Video System TVS-8500) immediately after exposure. The SAR values had been calculated from the temperature elevation in the sagittal plane of a rat phantom. Numerical dosimetry with the rat model which has the same shape and electrical properties as the rat phantom was also performed. The SAR values agreed between the experiment and calculation using homogeneous rat model (Fig.7). This suggests that the numerical dosimetry described above sections can appropriately simulate complex interaction between the antenna and the rat.

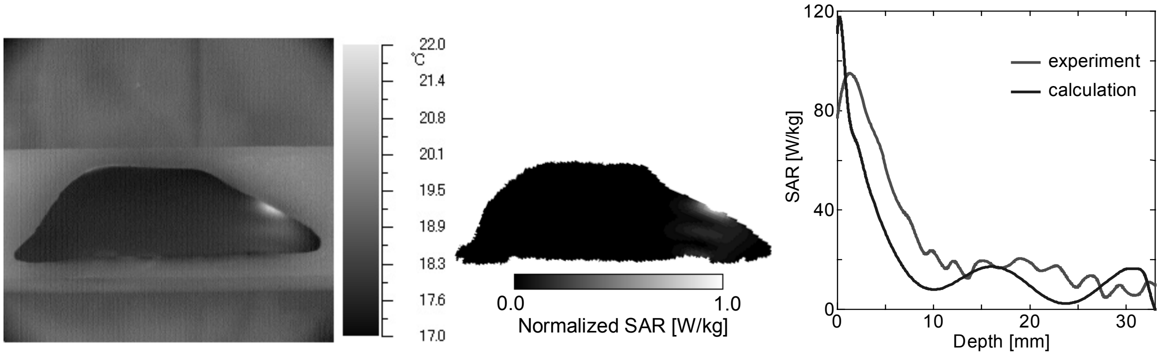

Figure 7: Comparison between calculation and experiment: Temperature distribution in rat phantom (left), SAR distribution in homogeneous rat model (center), and calculated and measured SAR distributions along the axis through the center of the brain from top surface of the brain to bottom of the head (right). SAR values are normalized as the antenna output power is 1 W.

4. Conclusion

The 8-shaped loop applicator optimized, based on numerical dosimetry to produce uniformly and high SAR within the target region. Experimental dosimetry has also been performed. The measured SAR values agreed with the numerical values, which suggest the validity of the numerical dosimetry.

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