Assessment of Absorbed Power Density for Curved Body Models

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The use of high frequencies has been increasing in order to achieve high-speed and large-capacity wireless communication. As the frequency of electromagnetic waves goes up, a large portion of the electromagnetic waves are absorbed by the human body surface. Therefore, the absorbed power density (APD) was introduced as an evaluation quantity for local exposure at frequencies over 6 GHz in the guideline for electromagnetic wave exposure [1]. APD is defined using the power density that penetrates the human body surface or the power loss near the body surface. When the APD values are calculated using different definitions, variations may occur, particularly on curved surfaces. However, it is difficult to adopt a unified evaluation definition for all assessments due to limitations in measurement and numerical simulation methods. For instance, numerical simulations using the boundary element method allow for easy calculation of electromagnetic fields on the surface, resulting in the use of power density on the human body surface. On the other hand, the use of the finite difference method makes it difficult to obtain the surface electromagnetic field on curved surfaces, leading to evaluations based on power loss within the human body. Therefore, when comparing results, it is necessary to investigate not only differences due to simulation methods but also differences due to evaluation methods of APD. In this study, the APD on curved surfaces was evaluated using the evaluation formulas ranging from 10 GHz to 30 GHz.

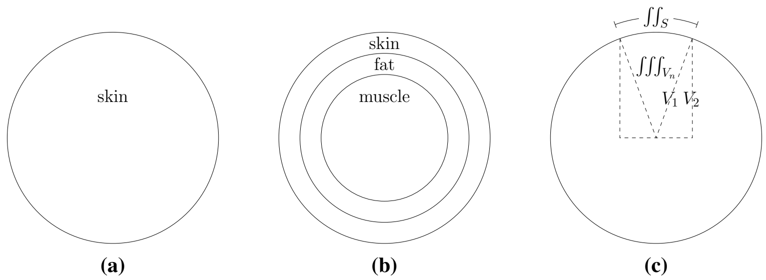

Figure 1. (a) (b) 1 and 3 layer models with different tissues. (c) Integration area and volume for calculation of absorbed power density.

Figure 1(a), (b) show the evaluation models with a curved surface. Two types of models were used: a one-layer homogeneous dielectric sphere model with electrical constants of the skin and a three-layer model composed of the skin, fat, and muscle. The averaging area for APD is set to 4cm^2, and two volumes are considered, as shown in Figure 1(c). The surface and internal electromagnetic fields were calculated by Mie theory when exposing these models to a plane wave. When evaluating the difference between the values using volume integration with reference to the power density passing through the surface, it was found that for a radius of 20mm, the differences were found to be within 25% and 4% at 10GH and 30GHz, respectively. The difference decreased as the radius increased, and when the radius was 80mm, the difference was below 5% and 2%, respectively.

Acknowledgment

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References

[1] International Commission on Non-Ionizing Radiation Protection (ICNIRP), “Guide lines for limiting exposure to electromagnetic fields (100 kHz to 300 GHz),” *Health Phys.*, vol. 118, no. 5, pp. 483–524, May 2020.