Preliminary Results of Thermal Effects due to Mobile Phones

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ABSTRACT

Public concerns associated with the electromagnetic field (EMF) exposures from mobile phones on human body are increased. Although studies on the effects of the EMF exposures on human have been carried out for a long time, it is not proved yet whether the EMF effect is harmful or not. Based on the scientific results by experts, EMF exposure limits have been regulated as a precautionary approach on the assumption that the EMF effect may be harmful.

It is well known that absorbed EMF can be transformed into heat within biological tissues and that thermal effects are related with the specific absorption rate (SAR) distribution. However, the relative magnitude and distribution of the energies are not well defined. Although there is comprehensive information of the thermal effects, most of them come from animal and in vitro studies. Considerable efforts have been made to analyze the EMF absorption model while the actual temperature in the human body has been rarely measured.

Temperature changes on the face of a healthy male volunteer were studied. A digital mobile phone of 1.8GHz was used. A digital infrared imaging system (IRIS-5000, Medicore, Seoul, Korea) was applied to take infrared pictures of the face every minute while the volunteer talked over the mobile phone for 20 minutes. The specification of the imaging system was as follows: Temperature resolution = 0.1℃; Range of temperature measurement = 17~40℃; Pixel size = 0.9mm x 0.9mm; Frame time = 2.6s; Active temperature of detector = 77°K.

The result showed that temperature of the ear region was increased during the phone call and the region of the temperature increase on the face was expanded as the phone call time increased. Further study is necessary to investigate the temperature rise analytically and quantitatively.

Keywords: EMF, thermal effect, mobile phone

1. INTRODUCTION

Public concerns associated with the electromagnetic field (EMF) exposures from mobile phones on human body are increased. Although studies on the effects of the EMF exposures on human have been carried out for a long time, it is not proved yet whether the EMF effect is harmful or not. Based on the scientific results by experts, EMF exposure limits have been regulated as a precautionary approach on the assumption that the EMF effect may be harmful.

The averaged specific absorption rate (SAR) for the whole body is set to less than 0.4W/kg and this is based on various animal experiments of which results showed there were no advert health effects[1]. Although the threshold values of the body averaged SAR were based on biological researches, biological effects due to the local SAR were not identified properly yet. It is recommended that the local spatial maximum SAR is less than 1.6W/kg for 1g-tissue or less than 2W/kg for 10g-tissue while biological basis for these values are unclear. Since SAR is defined as the power per unit mass of the tissue, it could cause the temperature rise in the tissue. It would be helpful to investigate relationship between temperature increases and biological tissues exposed on EMF sources such as mobile phones. This approach could help the scientific researches to examine the biological effects due to the SAR variations.

It is well known that absorbed EMF can be transformed into heat within biological tissues and that thermal effects are related with the SAR distribution[2,3]. However, the relative magnitude and distribution of the energies are not well defined. Although there is comprehensive information of the thermal effects, most of them come from animal and in vitro studies. Considerable efforts have been made to analyze the EMF absorption model while the actual temperature in the human body has been rarely measured.

In this study, the temperature changes due to mobile phones were measured using the digital infrared imaging system.

2. METHOD

Temperature changes on the face of a healthy male volunteer were studied. A folder type digital mobile phone was used. The mobile phone operated at 1.8GHz and the maximum radiated power of the phone was 240mW. A digital infrared imaging system (IRIS-5000, Medicore, Seoul, Korea) was applied to take infrared pictures of the face of the subject every minute while the volunteer talked over the mobile phone for about 20 minutes. The volunteer was sat in front of the infrared camera during the measurement.

The specification of the imaging system was as follows: Temperature resolution = 0.1℃; Range of temperature measurement = 17~40℃; Pixel size = 0.9mm x 0.9mm; Frame time = 2.6s; Active temperature of the detector = 77°K.

3. RESULTS

After the phone call for about 20 minutes, it was observed that the temperature was increased significantly at the contact region of the mobile phone such as ear and cheek as shown in Fig 1. The temperature at the forehead was also increased The temperature increase after 17 minutes exposure was between 0.25℃ and 1.11℃. In addition, the region of the temperature increase on the face was expanded as the phone call time increased.

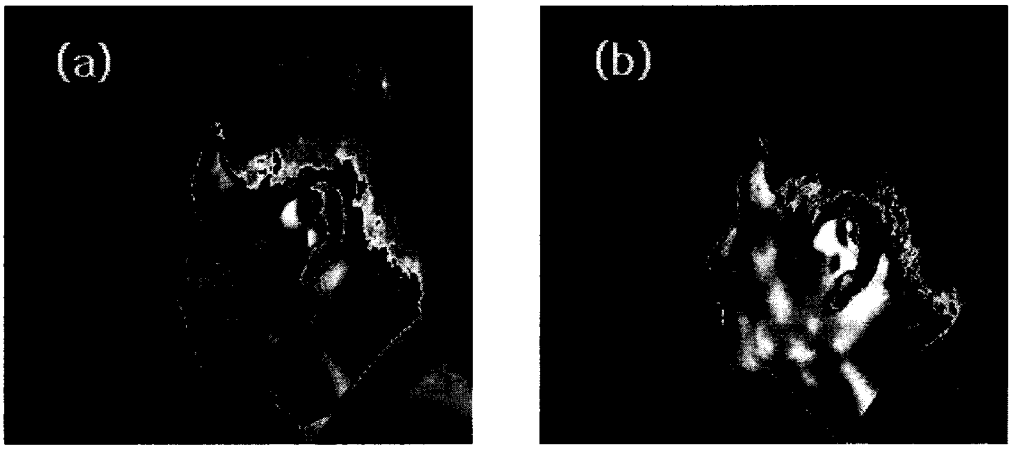

Figure 1. Thermographic images of the head: (a) without exposure and (b) after talking over the mobile phone for about 20 minutes

4. DISCUSSION

Researches for temperature changes due to mobile phones have not been studied actively around the world. The reason would be considered that there are a lot of restrictions for any researches directly using human bodies and various factors for the physiological phenomenon.

Details of the studies for temperature changes due to mobile phones were presented in Table 1. Taurisano *et al* and Leeuwen *et al* measured the body temperature directly while most of the studies were analytical simulations in order to estimate the temperature changes.

The operating frequencies of the mobile phones were between 800MHz and 1.8GHz and the exposure time was from 10 minutes up to 60 minutes. The power of the mobile phone in measurements and simulations was varied from 121mW to 2000mW. In five out of eight studies, ear was the region where the temperature was increased uppermost while skin was the region where the temperature was increased uppermost in the rest of the studies.

For temperature changes due to mobile phones, simulation values reported the body temperature increased between 0.2℃ and 1.6℃ while measurement values showed the temperature increased between 0.8℃ and 2.4℃. It should be noted that the measurement values were higher than the simulation values. It was difficult to compare the temperature values properly since the exposure time and the power were not the same in all the studies

Table 1. Studies for temperature changes due to mobile phones

Researcher	Frequency (Power)	Exposure time	Region	Temperature change (℃)
Bernardi[4] (C)	900 MHz (250 mW) 1.8 GHz (125 mW)	15 min	Ear	1.6 1.6
Gandhi[5] (C)	835 MHz (310 mW) 1.9 GHz (121 mW)	55 min	Pinna (Ear)	4.5 (1.0*) 4.5 (1.1*)
Lee[6] (C)	800 MHz (600 mW)	40 min	Skin (dry)	0.4
Bernardi[7] (C)	900 MHz (600 mW)	15 min	Ear	0.25-0.43
Taurisano[8] (M)	900 MHz	15-20 min	Ear	1.0-2.4
Van Leeuwen[9] (C, M)	915 MHz (1000 mW) 915 MHz (2000 mW)	10 min	Skin	0.6 (1 W, C) 1.3 (2 W, C) 0.8 (1 W, M) 2.0 (2 W, M)
Wang[10] (C)	900 MHz (1000 mW)	-	Skin	0.29 (Adult) 0.22 (Infant)
Wang[11] (C)	900 MHz (600 mW) 1.8 GHz (270 mW)	60 min	Ear	0.18 0.15

C: Calculation, M: Measurement

*Values with heating only without additional heating due to a warm (39℃) handset

In this study, the temperature changes due to mobile phones were measured using the digital infrared imaging system. The temperature of the ear region was increased during the phone call. The region of the temperature increase on the face was expanded as the phone call time increased. It should be noted that the temperature increase could be affected by several thermal sources such as EMF from the mobile phone, the battery heat and the body heat. It would be very difficult to distinguish thermal effects due to the individual heat sources in the experiment. Further study is necessary to investigate the temperature increase analytically and quantitatively.

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