# Estimation of the thresholds for corneal epithelium damage induced by millimeter-wave electromagnetic field exposure with a mathematical model based on CEM43°C criterion

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## Extended Abstract

It is expected that new millimeter wave (MMW) technologies, e.g. the 5th generation (5G) wireless systems, the Wireless Gigabit (WiGig) systems and so on, will be in wide spread use in near the future. Therefore, it is becoming public concern to consider the safety of the use of MMW technologies. However, a few studies for corneal damage thresholds by MMW exposure have been performed. Against this background, we conduct the study to estimate the threshold levels of ocular damage, especially within corneal region, under the MMW exposure from 40 GHz to 95 GHz.

The mathematical model is proposed to estimate the threshold incident power levels of MMWs based on CEM43ºC (cumulative number of equivalent minutes at 43ºC) [1] criterion. CEM43ºC criterion is the index of "thermal isoeffective dose", which is originally applied for cancer therapy from 1984. Corneal damage induced by MMW is mainly caused by thermal dose, therefore we think it is reasonable to introduce the CEM43ºC criterion to the estimation of the threshold.

Coupled analysis for electromagnetic field (EMF) and heat transport (HT) is performed from 40 GHz to 95 GHz with 100µm spatial resolution of rabbit and human eye model. In the heat transport simulation, convectional heat transfer model, driven by aqueous humor in the anterior chamber, is considered. 3D time development temperature distributions are obtained during MMW exposure by varying incident power density from 50 mW/cm$^2$ to 300mW/cm$^2$ at each frequency to obtain threshold. Moreover, 3D time dependent CEM43ºC index distribution within corneal region is calculated from these time dependent temperature data.

Threshold levels of incident power density for 360 s exposure time is estimated from these CEM43ºC data in the condition of acute and minor damage as for cornea, which was described in past literature as 21 < CEM43ºC < 40 min. [2] Consequently, threshold levels estimated by this mathematical model is fairly consistent with threshold level of the damaging dose, 50% (DD50) obtained by in vivo experiment as shown in Fig. 1. We think our proposed model with CEM43ºC criterion is feasible to estimate threshold power levels for corneal damage.

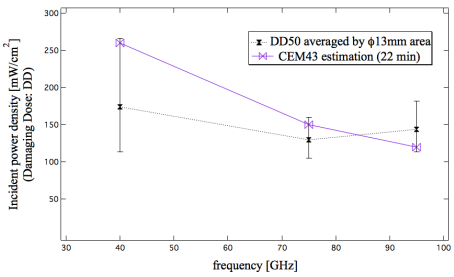


**Figure 1.** Comparison of the threshold incident power levels between the mathematical model based on the CEM43ºC criterion and the DD50 experimental data with the probit analysis.

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## References

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