Risk Assessments Methodologies and Recommendations for RF Workers with various types of Metallic Implants working in close proximity to Mobile Base Station Antennas

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Introduction

The ICNIRP [1] and IEEE [2] Radio Frequency exposure guidelines do not explicitly address exposure of individuals with metallic implants. These guidelines do however recognise that an increased local SAR due to such implants is possible, depending upon the size and shape of the implant, and the position thereof within the body[2] (p131-132).

In accordance with the IEEE Recommended Practice for RF safety programs [3] and a RF safety program developed for Mobile Network installation and maintenance personnel, all individuals having either metallic and/or electronic implants should be assessed prior to being exposed to the upper tier limits.

The work presented spans four years of actual assessments for a mobile network operator where 4% of RF workers trained in exposure awareness have indicated that they have a form of metallic implant. This has led to a new simplified method of assessing the risk of overexposure of such individuals in a considerably shorter period of time.

Materials and Methods

Numerically assessing the effect of a metallic implant on the RF exposure of individuals for all possible incident angles and at all relevant frequencies is impractical, and would require excessive amounts of processor time. Instead making use of an understanding of the expected effects caused by the presence of the implant gives way to an effective means of finding the incident angle and frequency most likely to cause an increase in the 10g local peak spatial average SAR (local peak SAR). A sufficiently large section of the phantom around the implant is simulated with planar wave illumination from the 6 principle directions, both vertically and horizontally polarised, over a frequency range from 100 MHz to 3 GHz with a 100 MHz step. The simulations are performed for both the “with-” and “without-implant” cases, and by means of a reduced complexity local peak SAR approximation, a SAR enhancement factor is calculated. This then, when ranked against all possible combinations, allows for the choice of a selection of cases which are simulated within the full inhomogeneous phantom. The full phantom simulations are again performed with and without the implant to verify the enhancement factor determined earlier. This allows for a determination of the actual local peak and whole body SAR perturbations due to the implant, forming the basis for a recommendation as to whether the individual is at an undue increased risk of localised overexposure when exposed to the upper tier limits.

Results

In the example selected for this paper an individual having a full length metallic femur implant is assessed for safety around mobile base station antennas. The metallic implant modelled from x-rays, is simulated in the truncated section of the phantom from 100 MHz to 3 GHz with planar wave radiation originating from the 12 orthogonal directions. The largest simplified local peak SAR enhancement factor of 97 is found at 100MHz, illuminated from the top side, with a front to back polarisation. This enhancement factor is illustrated in Figure 1 using a clamped dB scale. The peak enhancement position is indicated with crosshairs.

This case now simulated in the full inhomogeneous phantom, again with and without the implant, gives an enhancement factor in the vicinity of the implant of 93, a confirmation that the truncation section used with the bulk simulations was large enough. The position of the maximum enhancement is also expected at the lower end of the implant as shown in Figure 2. For this case, however the whole body average SAR and local peak SAR (in the full phantom), with and without the implant, remain unchanged at 4.5% and 1.4% of the ICNIRP Occupational basic restriction level, respectively. This is because the location of this specific implant is deep beneath the tissue and the actual RF energy reaching it is low. The local peak SAR around the implant thus increases significantly but still remains lower than the maximum local peak SAR in the full body found close to the surface (as indicated in Figure 2).

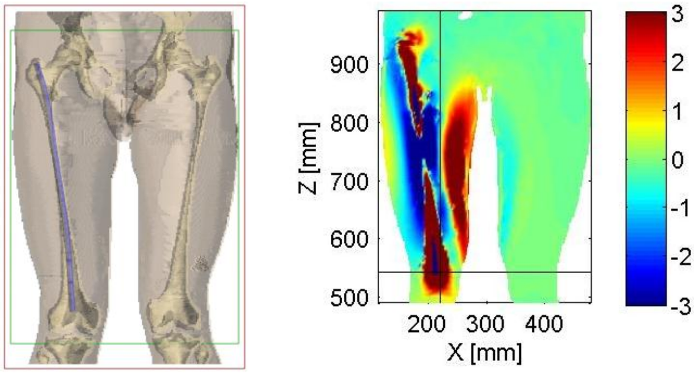

Figure 1:Metal implant, the truncated phantom section and the SAR enhancement factor in dB

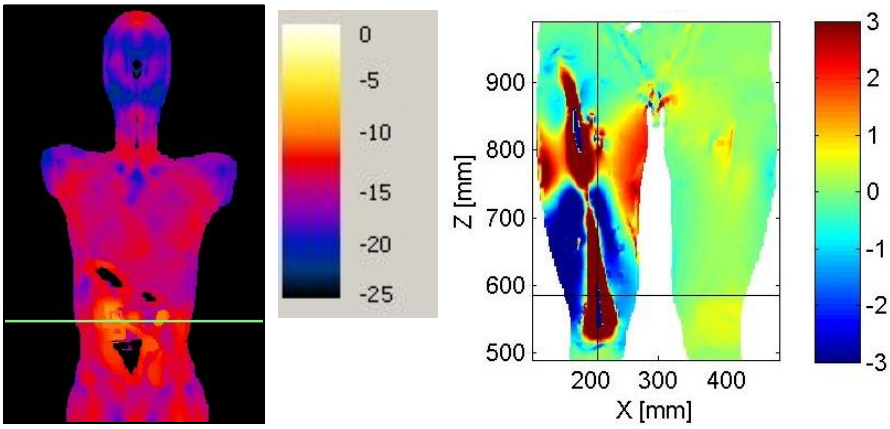

Figure 2:Local peak SAR position within the full inhomogeneous phantom, and the SAR enhancement factor in dB

The procedures and methodologies detailed thus far have been externally reviewed [4] and applied to knee replacements, hip replacements, spinal and vertebrae fusions. In all cases investigated there was no increased risk of basic restriction overexposure when exposed to the upper tier reference field levels. All these types of implants can now be assessed much quicker based on similarity to those analysed before.

Summary and Conclusions

Accelerating the process of analysing the impact of a metallic implant upon the local peak and whole body average SAR of an individual exposed to upper tier RF limits, has led to the formulation of implant groups showing no increased risk of over exposure. This has led to a further advantage in that individuals requiring pre-screening for deployment in such areas can be given a risk assessment in a short period of time, with only special cases requiring a full assessment.

References

[1] International Commission on Non-Ionizing Radiation Protection. 1998. Guidelines for limiting exposure to time-varying electric, magnetic, and electronic fields (up to 300GHz). *Health Phys*, vol(74): 494-522.

[2] Institute of Electronic and Electrical Engineers. 2005. IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz. New York: IEEE International Committee on Electromagnetic Safety (SCC39). IEEE Std C95.1

[3] Institute of Electronic and Electrical Engineers. 2005. IEEE Recommended Practice for Radio Frequency Safety Programs, 3 kHz to 300 GHz. New York: IEEE International Committee on Electromagnetic Safety (SCC39). IEEE Std C95.3

[4] D.R. Black, *Review of EMSS Methodology for Increased Risk Assessment of RF to Workers*, ITMEDICAL LTD, October 2008.