Bone & Joint Research

Pijls BG, Sanders IMJ, Kuijper EJ, Nelissen RGHH. Non-contact electromagnetic induction heating for eradicating bacteria and yeasts on biomaterials and possible relevance to orthopaedic implant infections: *in vitro* findings. *Bone Joint Res* 2017;6:323-330.

https://doi.org/10.1302/2046-3758.65.BJR-2016-0308.R1

Authors' reply:

15 August 2017

Sir,

We have read with great interest the comments by Mortazavi and Mortazavi in response to our paper.[1]

They raise some interesting points. However, we question whether ultrasound can be used to selectively heat the metal implant, especially for (partially) intramedullary devices such as intramedullary nails or total hip stems. Also, the papers they presented about induction heating and antibiotic resistance are inconclusive.

Regarding ultrasound to heat the metal implant
Contrary to induction heating, the absorption of the ultrasound energy is not specific to metal.[2,3] Soft tissue and bone also absorb ultrasound energy and are thus heated. Andrades et al[2] have shown that cortical bone absorbed more ultrasound energy than the metal plate.[3] The unspecific heating of ultrasound risks osteonecrosis of the bone and necrosis of the soft tissue and possible loosening of the prosthesis. Furthermore, absorption and reflection of ultrasound energy by the cortical bone, acoustic shadowing, greatly impedes heating any metal implant that is situated (partially) intramedullarly such as an intramedullary nail or total hip femoral stem.[2,3]

Regarding the statement that exposure of radiofrequent electromagnetic fields (RE-EMF) can make micro-organisms resistant to antibiotics, we would like to point out that the frequencies used in the studies provided by Mortazavi and Mortazavi are 0.9 GHz and 2.4 Ghz, which are several orders of magnitude different from the 27 kHz used by our group (and relevant for heating metal): the frequency used in our paper is 100 000 times less than 0.9 GHz to 2.4 GHz. Hence, alleged antibiotic resistance caused by radiofrequent fields of 0.9 GHz to 2.4 GHz is very likely not relevant for the frequencies used to heat metal (27 kHz in our paper).[1] Moreover, Pickering et al have shown a synergistic effect of antibiotics and pulsed electromagnetic field therapy (PEMF): exposure to a PEMF at 72 Hz increased the effectiveness of gentamicin against five-day biofilms of *Staphylococcus epidermidis*.[4]

Second, we are not convinced that exposure to RF-EMFs can make micro-organisms resistant to antibiotics[5,6] since antibiotic susceptibility was tested by disk diffusion method (Kirby-Bauer method). Changes assessed by inhibition changes in zone diameter were significant, though minor and not impressive, and unfortunately not confirmed by a broth dilution assay to determine the precise changes of minimal inhibitory concentrations (MIC) for each of the tested antibiotics.
The arguments for inducement of antibiotic resistance by PEMF in the frequencies used for heating metal, given by Mortazavi et al, are far from conclusive. As there is currently no high-quality evidence for or against, we will consider investigating the possibility of inducing antibiotic resistance by PEMF (with frequencies used for heating metal) in future studies.

B. G. Pijls, Orthopaedic Resident, Epidemiologist,
Department of Orthopaedics, Leiden University Medical Center,
Leiden, The Netherlands.
I. M. J. G. Sanders,
E. J. Kuijper,
R. G. H. H. Nelissen

1. **Pijls BG, Sanders IMJG, Kuijper EJ, Nelissen RGHH.** Non-contact electromagnetic induction heating for eradicating bacteria and yeasts on biomaterials and possible relevance to orthopaedic implant infections: *in vitro* findings. *Bone Joint Res* 2017;6:323-330.
2. **O'Brien WD Jr.** Ultrasound-biophysics mechanisms. *Prog Biophys Mol Biol* 2007;93:212-255.
3. **Andrades AO, Mazzanti A, Beckmann DV, et al.** Heating produced by therapeutic ultrasound in the presence of a metal plate in the femur of canine cadavers. *Arq Bras Med Vet Zootec* 2014;66:1343-1350.
4. **Pickering SA, Bayston R, Scammell BE.** Electromagnetic augmentation of antibiotic efficacy in infection of orthopaedic implants. *J Bone Joint Surg [Br]* 2003;85-B:588-593.
5. **Taheri M, Mortazavi SM, Moradi M, et al.** Evaluation of the Effect of Radiofrequency Radiation Emitted From Wi-Fi Router and Mobile Phone Simulator on the Antibacterial Susceptibility of Pathogenic Bacteria Listeria monocytogenes and Escherichia coli. *Dose Response* 2017;15:1559325816688527.
6. **Taheri M, Mortazavi SM, Moradi M, et al.** Klebsiella pneumonia, a Microorganism that Approves the Non-linear Responses to Antibiotics and Window Theory after Exposure to Wi-Fi 2.4 GHz Electromagnetic Radiofrequency Radiation. *J Biomed Phys Eng* 2015;5:115-120.

Conflict of interest: None declared