IF MAGNETIC RESONANCE IMAGING OF HUMAN BRAIN IS HARMFUL?

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In human brains, there are a lot of macroscopic (~100 nm) magnetite granules. Exposure of the patient head in high enough magnetic field could lead to penetrating those particles in brain's neurons and their staying there for a long period. The role of iron in the brain metabolism is not conclusively clear but there are many evidences on the connection between iron excess and neurodegenerative diseases. In this regard, we consider it necessary to look more carefully at the matter of safety for the brain magnetic resonance imaging.

20 years ago J.L. Kirschvink et al. [1] established, with the help of ultra-sensitive magnetometric investigations, the existence of ferromagnetic inclusions in human brain tissues. Electron microscopy and diffraction along with the element analysis showed that those are magnetite nanocrystals Fe_3O_4 (or $Fe^{2+}Fe_2^{3+}O_4$) with typical sizes of 10-200 nm. The concentration of such granules varies from ~ $5 \cdot 10^6$ per gram in the brain itself to ~10^8 per gram in dura and pia matter.

Mentioned ferromagnetic granules are situated in the inter-cell brain space. With their high (due to the single-domain magnetic structure) magnetic moment, they could experience strong mechanical forces and/or mechanical moments under external magnetic field. That is especially important in high magnetic fields which are used in diagnostic apparatus like magnetic resonance tomograph (MRT) with the field of H~10^4 Oe.

As a result, those granules would tend to move or turn, having an effect on the neighboring brain elements (neurons, ganglion cells, axons, etc.). This should result in the membrane tearing and penetrating the tip into the inner part of the neuron.

The situation before switching the field out differs principally from that before its switching on: big axes of all granules are now directed along the field and all mechanical moments equal zero. Then switching the field out does not lead to appearing either forces affecting granules, and those stay in the state of partial penetrating into the depth of neuron cells (at least, up to the next MRT session).

Hence, exposure of the patient head in high enough magnetic field could result in penetrating large iron-containing particles (magnetite) into neurons and staying there for a long time. The role of iron in the brain metabolism is not clear conclusively, but there are many evidences about connection of iron excess with neurodegenerative diseases, such as Alzheimer's and Parkinson's diseases. Thus, there arises the question: “Could magnetic granules in magnetic field put so strong impact on the brain elements that some of them turn out to be injured?” Our estimates say “Yes”.

From the aforesaid, we consider necessary to come down more carefully to the point of safety for procedures exploiting instruments for magnetic resonance imaging of the human brain.

1. Kirschvink, J.L., Kobayashi-Kirschvink, A., Woodford, B.J., Magnetite biominaralization in the human brain, PNAS, **89**, 76-83 (1992).