Title: Simulations on Magnetically Induced Torque on Medical Implants

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Structured Abstract:
Introduction. Since 2012, there has been consistent net growth in the usage of MRI as a diagnostic tool. In parallel, the growth in the usage of implantable medical devices poses a potential risk to patients who are referred to an MR exam. This presents a challenge to device manufacturers, who are required to assess all potential risks of their product in MR for regulatory labeling. Devices however, often exist a family of related devices varying in size, orientation, and material. It becomes impractical to experimentally test for every configuration. The objective is therefore, to develop a simulation so that we can have the capacity to identify from a device family, the worst configuration. Experimental testing on the worst configuration can serve as a conservative limit for device compatibility.

Methods. Numerical computation relied on commercial software, namely COMSOL Multiphysics (COMSOL Inc., Sweden), with the exported data analyzed in MATLAB (Mathworks Inc., USA). In part 1, The B fields of two simple geometries, a long cylinder and sphere, with known analytics were modeled. The validity of the numerical method was determined by making a linear plot of the numerical and analytical datasets and finding the coefficient of determination. When the analytical value was constant, the percent difference between the mean of the distribution from the numerical method and the analytical value was used. In part 2, a set of cylinders with varying lengths were modeled in standard test conditions. The induced torque on each cylinder was calculated from the B field. They were ranked from least to greatest risk by torque and the worst configuration was identified.

Results. From part 1, the coefficient of determination between numerical and analytical values of the B field outside of a long cylinder and sphere were found to be 0.99992 and 0.99977 respectively. The percent difference between the same datasets and objects were found to be 0.22% and 0.40% respectively. From part 2, with a constant radius, as length increased, the maximum induced torque for each cylinder increased as well. The worst configuration from this set of cylinders is the longest one.

Discussion. From the results, it can be concluded that the parameters chosen for the numerical computation provide results that reflect what would be expected in theory. Furthermore, the simulations showed that with increased length, the induced torque increased as well. This is consistent with what one would expect to find should physical cylinders be machined and tested. Future steps will include a more realistic model such as a plate with screws. With varying length of the plate, number of screws held, and the size of the screws, it is already difficult to anticipate the worst configuration for such a model. We anticipate to have a fast and systematic method of assessing medical devices and the capacity to provide manufacturers with the necessary safety information of their product.