Assessment of Magnetic Field Interactions at 1.5- and 3-Tesla for Implantable Pulse Generators and Receivers Used for Neurostimulation Systems

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BACKGROUND: Neurostimulation systems are used to treat a variety of neurological and psychiatric conditions. The use of MR procedures is often desirable for the evaluation of patients with neurostimulation systems. To date, little attention has been given to evaluating magnetic field interactions for implantable pulse generators (IPGs) and RF receivers used for neurostimulation systems.

PURPOSE: To evaluate the magnetic field interactions at 1.5- and 3-Tesla of IPGs and RF receivers commonly used for neurostimulation systems.

MATERIALS AND METHODS: Seven different IPGs [Kinetra, Synergy, Synergy Versitrel, Itrel 3, Itrel II (older version), Itrel II (present version), Soletra; Medtronic, Minneapolis, MN) and three different RF receivers (Mattrix, Xtrel, and SE-4; Medtronic, Minneapolis, MN) were evaluated for magnetic field interactions in association with exposure to 1.5- (Magnetom Symphony) and 3-Tesla (Allegra) MR systems (Siemens Medical Solutions, Malvern, PA). Translational attraction was assessed at various positions in the MR systems using a standardized technique **(1)**. Torque was measured along the three orthogonal axes for each device using a digital force gauge connected to a low-friction turntable placed in the center of the 1.5-Tesla and 3.0-Tesla MR systems.

RESULTS: Four IPGs exhibited force ratios (magnetic attraction force / device weight) greater than 1.0, with the overall magnitude of the force ratio increasing significantly from the 1.5-Tesla to the 3.0-Tesla MR system. Of the seven IPGs tested, only one exhibited a torque ratio (magnetic induced torque / product of the device weight and length) greater than 1.0. The RF receivers displayed substantially stronger magnetic field interactions at both 1.5- and 3.0-Tesla, with the minimum force and torque interactions across the group being on the order of nine times that expected from exposure to gravity. As illustrated in Figure 1, the amount of induced force or torque interacted significantly with the test position or orientation of the device, respectively.

CONCLUSIONS: Five of the seven IPGs were considered to fall within a safe range, as the values for translational attraction and torque at 1.5- and 3-Tesla were less than that which may pose a risk in consideration of the intended *in vivo* uses of these devices. On the other hand, the three RF receivers (Mattrix, Xtrel, and SE-4) exhibited substantial translational attraction and torque, suggesting that these devices may experience movement and cause substantial discomfort to patients undergoing MRI. Finally, the interaction between the device position or orientation and the amount of induced force or torque, respectively, reinforces the need to consider practical issues related to the design and probable placement of an implant when evaluating potential magnetic interactions.

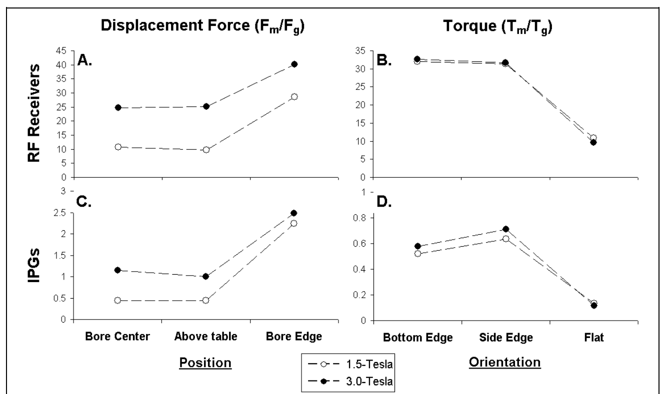

Figure 1. Average displacement force (A & C) normalized to the gravity force and torque (B & D) normalized to the gravity torque for the RF receivers (A & B.) and the IPGs (C & D).

REFERENCES

(1) ASTM Designation - F 2052;13.01:1576-1580.