Measuring the Spatial Magnetic Field Gradients within a Scanner Bore

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Target audience: Although the use of magnetic resonance (MR) as a diagnostic imaging tool has been in existence for many years, there is now a growing need for manufacturers to produce medical implants and devices which can be classified as MR conditional, if not MR safe. The usual condition specified by the manufacturer is the *maximum* spatial magnetic field gradient (MFG), which is a measurement of the difference in magnetic field strength between two known points as expressed in Gauss per centimetre (G/cm) or Tesla per metre (T/m).[1] This condition for safe operation should be reviewed and considered by MR Operators during the subject screening process, along with the scanner specific maximum spatial MFG expressed by MR scanner manufacturers, prior to scanning being allowed.

Purpose: The purpose of this project was to determine the spatial MFG present within the patient accessible areas of our MR scanners, and compare the results to those given by the scanner manufacturer.

Methods: Measurements were obtained from two GE Signa TwinSpeed HD.x (1.5T & 3.0T) MRI scanners, and two GE Discovery MR750 3.0T scanners, using a 2-dimensional template made out of sturdy cardboard to represent the internal axial dimensions of each scanner bore. A 10cm vertically and horizontally-lined grid was marked on the template with Y incrementing anteriorly from zero at the bottom, X incrementing laterally from zero at the centre, and with the laser lights corresponding to the intersecting point X=0, Y=0, Z=0. The strength of the magnetic field at each point on the template was measured in kG using a THM1176 Hall probe commencing with the position Z=0, and repeated at 10cm increments along the Z axis of the scanner bore. Separate gradient calculations were made for each orthogonal direction, followed by the vector sum of the 3 gradients.

Results: The strongest gradients (G/cm) for all scanners were found along the Z axis, with gradients in the X & Y directions comparatively negligible, and with the vector sum values approximating the Z gradients. Gradients higher than 500 G/cm for the 3.0T scanners and 350 G/cm for the 1.5T scanner, where found around the perimeter of the bore, and within 20cm and between 10 and 20cm of the bore respectively. The maximum gradient value for each 3.0T scanner was over 700 G/cm, whereas the 1.5T scanner had a maximum gradient value of just over 400 G/cm. The 1.5T scanner and one of the 3.0T MR750 scanners each had their maximum gradient value located at the left edge of the bore 10cm above the couch, whereas the remaining two 3.0T scanners were found to have their maximum gradient value at the top centre of the bore ~40cm above the couch (Figure 1a-d). The maximum gradients as reported by the manufacturer[2] were respectively 650 G/cm, 1490 G/cm and 1390 G/cm for the 1.5T & 3.0T HD.x scanners and the two 3.0T MR750 scanners.

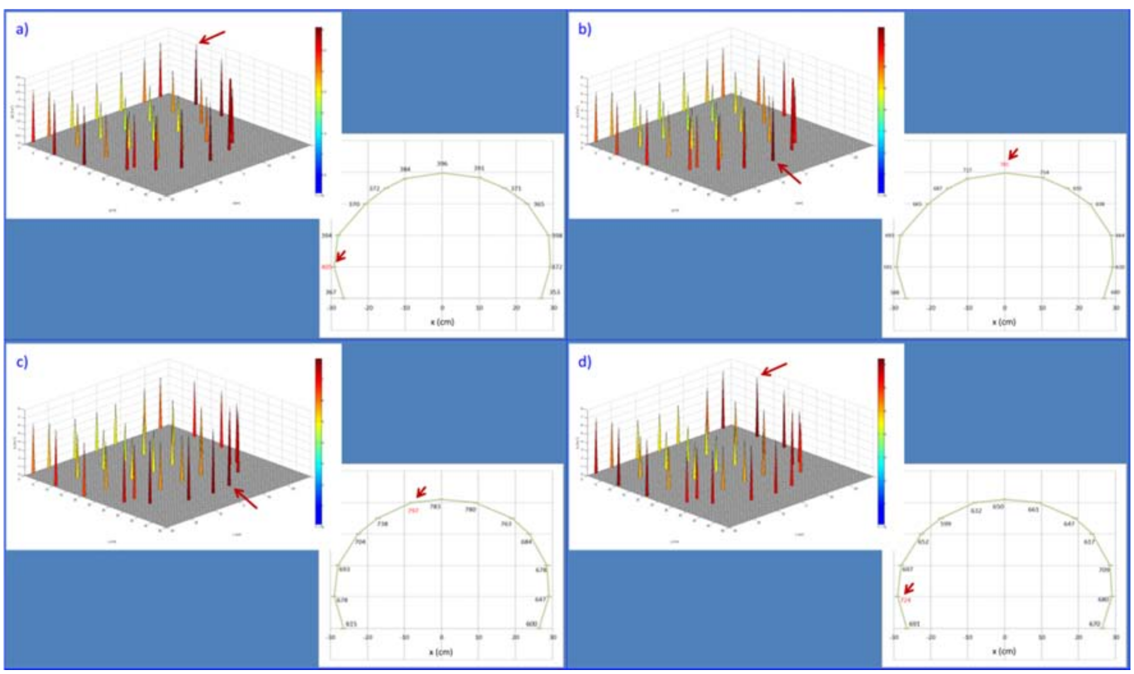

Figure 1: Spatial magnetic field gradient values for each scanner (shown at their strongest position along Z) are depicted on the perimeter of the template diagram, and on a rotated 3D rendering of gradient 'spikes', where the maximum gradient value from each scanner is indicated a) 1.5T HDx, b) 3T HDx, c) 3T MR750 (1), d) 3T MR750 (2)

Discussion: Although our MR scanner manufacturer reported their maximum spatial MFG values to be approximately 1.5 and 2 times that of our local calculations for the 1.5T and 3.0T scanners respectively, the location of these values expressed in cylindrical coordinates originating at the magnet isocentre cannot be explicitly compared. However, if we exclude the radial component of the cylindrical coordinate location which places the maximum spatial MFG behind the scanner covers, the remaining Z component then compares to our Z axis component in 3 out of 4 occasions.

Conclusion: Had the manufacturer's measurements been restricted to the patient accessible area, our measurements may have been more comparable.

References: **1.** Shellock FG, Kanal E, Gilk TB, Am J Roentgenol. 2011 Jan; 196(1):142-5; **2.** G.E., 2009, Appendix D-E, 2381696-100 Rev.10