Purpose: To achieve real-time image guided radiotherapy, a linac-MR system is designed with the linac located on the symmetry axis of the MRI. Thus, an investigation was performed in order to determine the performance of an in-line 6 MV linac in longitudinal magnetic fields.
Method and Materials: Magnetic fringe fields from the PARAmed openMR™ were modeled and included in the simulation of an in-line 6 MV linac. The electron gun simulation was modeled in OPERA-3d/SCALA. The linac waveguide emulating the Varian 600C was modeled in COMSOL and the resulting dosimetry from the linac model was calculated using BEAMnrcMP 2007 and DOSXYZnrc.
Results: With the linac on the symmetry axis of the openMR™ imager, the electron gun is expected to experience longitudinal magnetic fields ranging from 0.0022 to 0.011T. At these field strengths, the rms emittance of the electron beam injected into the waveguide grew from 0.358 pi-mm-mrad at 0T to 3.255 pi-mm-mrad at 0.011T. The increased emittance resulted from an increased beam diameter and an increasingly diverging beam. Upon injection, the larger emittance caused greater beam loss within the waveguide and a two orders of magnitude increase in the full-width-half-maximum of the focal spot at the target. Despite the changes in the focal spot, the mean energy was altered by less than 0.5% and the calculated depth dose and profile distributions were identical to distributions at 0T. Magnetic fields up to 0.2T were also added to the linac simulation representing fringe fields from other MRIs. Both the injection current and target current reached a minimum at 0.06T, but increased slightly at higher field strengths due to increasing collimation in the electron gun anode.
Conclusion: The effect of longitudinal magnetic fields on a simulated in-line 6 MV linac has been quantified enabling future development of a parallel linac-MR system.