Purpose: In-vivo PET range verification relies on the comparison of measured and simulated activity distributions. The accuracy of the simulated distribution depends on the accuracy of the Monte Carlo code, which is in turn dependent on the accuracy of the available cross sections data for β+ isotope production. We have explored different cross section data available in the literature for the main reaction channels (16O(p,pn)15O, 12C(p,pn)11C and 16O(p,3p3n)11C) contributing to the production of β+ isotopes by proton beams in patients.
Methods: Available experimental and theoretical values were implemented in the simulation and compared with measured PET images obtained with a high-resolution PET scanner. Each reaction channel was studied independently. A phantom with three different materials was built, two of them with high carbon or oxygen concentration and a third one with average soft tissue composition. Monoenergetic and SOBP field irradiations of the phantom were accomplished and measured PET images were compared with simulation results.
Results: Different cross section values for the tissue-equivalent material lead to range differences below 1 mm when a 5 min scan time was employed and close to 5 mm differences for a 30 min scan time with 15 min delay between irradiation and scan (a typical off-line protocol).
Conclusion: The results presented here emphasize the need of more accurate measurement of the cross section values of the reaction channels contributing to the production of PET isotopes by proton beams before this in-vivo range verification method can achieve mm accuracy.