Purpose:We have developed a novel dose calculation algorithm, a spatial re-sampling pencil beam algorithm (SR-PBA), to improve the pencil-beam dose accuracy in heterogeneous regions of a patient's body.
Methods:The SR-PBA employs more sub-beams and splitting compared with previous methods. Sampling map analysis, which is another important concept of the SR-PBA, is preprocessing to determine the physical parameters of re-sampled sub-beams at sampling plane in order to avoid a time-consuming problem. We verified the superiority of the SR-PBA method to the conventional PBA by comparing their calculation results with the experimentally measured dose distributions in the heterogeneous slab phantoms. In order to evaluate the depth dependence of the accuracy in the slab, we designed an L-shaped range compensator and two phantoms (A and B) in which low-density regions were placed.
Results:In a phantom A, the density interface was located at a shallow region, which corresponds to the plateau of the depth-dose curve. On the other hand, in a phantom B, the interface was located at a deep region, which is close to the proton range. The lateral dose distributions were measured using a two-dimensional detector. In both phantoms, the lateral-dose profiles showed the dose reduction in the vicinity of x = 0 mm. In the phantom A, the PBA could not reproduce this dose reduction with +10.7 % at x = 0 while the SR-PBA could within 1.5 % when the setup error of 1 mm was taken into account. In the phantom B, only the SR-PBA could reproduce this dose reduction with 0.4 % at x = 0. We found that the SR-PBA reproduced the dose reduction/increment at the dose profiles of the heterogeneous slab regardless of the depth dependence.
Conclusions:This study suggests that our proposed algorithm is feasible for simulating proton dose distributions in the practical proton therapy.