Purpose: Using Monte Carlo (MC) simulations and measurements, to develop a new treatment technique for the delivery of TBI at extended SSD using a custom modified Co-60 unit equipped with flattening filter and modular, patient-specific compensators.

Methods: An existing Eldorado-78 Co-60 teletherapy unit was stripped from its original collimator and equipped with beam-defining cerrobend blocks for extended SSD TBI treatments. An acrylic flattening filter was numerically designed based on detailed mapping of the dose distribution of the large open field at 10 cm depth in water using a primary radiation attenuation calculation. An EGSnrc MC model of the resulting unit was developed and experimentally validated. The model was used to calculate MC dose in whole-body supine and prone CT images of a patient. The total dose, calculated by summing prone and supine dose after deformable registration (VelocityAI™) was used to design modular, patient-specific compensators, based on the premise that dose in the patient mid-plane ought to be uniform.

Results: The designed flattening filter flattens the beam to within ±2% over a 200 cm x 70 cm area at 10 cm depth in water. Experimental validation of the calculated dose profiles in the open and flattened beams shows agreement of better than 2% and 1%, respectively. Patient MC dose calculations in the flattened, uncompensated beam showed dose deviations from prescription dose most notably in lung, neck, arm and leg areas ranging from -5% to +25%. Patient-specific compensation reduced non-homogeneities in the patient to within -5% to +10%. The clinical implementation involves a modular, Lego®-style realization of the compensator using orthogonal parallelepiped blocks on a plate that slides in the treatment head tray.

Conclusions: This work demonstrates that a Co-60 TBI setup combined with patient-specific compensators numerically designed using MC calculations is clinically feasible and highly improves the quality of the treatment.