Statistical analysis for determining initial electron beam parameters in a 6MV Linac: A simulation study

[1]*Department of Biomedical Engineering and Research Institute of Biomedical Engineering, College of Medicine, Catholic University of Korea*
[2]*Department of Nuclear Engineering, Hanyang University College of Engineering*
[3]*Department of Radiation Oncology, Ilsan Paik Hospital*
[4]*Department of Neurosurgery, Seoul National University College of Medicine*

Hye Jeong Yang[1], Tae Hoon Kim[2], Thomas Schaarschmidt[2], Dong-Wook Park[3], Hyun-Tai Chung[4*], Tae Suk Suh[1*]

Purpose: The purpose of this study was to obtain the initial electron beam parameters of a medical linear accelerator (Linac) with Monte Carlo (MC) simulations using the Geant4 code. The authors employed a statistical method to determine the optimal conditions for the first time.

Materials and Methods: For MC beam commissioning, a 6 MV Varian Clinac iX was simulated using the Geant4 toolkit, ver. 10.03. Dose calculation was performed in a water phantom. This study investigated the relations between the simulated dose distribution and several major initial electron beam parameters, namely mean energy, radial intensity distribution, and energy spread. The authors attempted to optimize these parameters to validate the Linac model. Calculated values for percentage depth dose and profile dose were compared with measured data. Subsequently, we have statistically approached to analyze correlations between the initial electron beam parameters and resulting dose distributions and to determine the best combination using the logistic regression method.

Results: 94 results with the MC simulation were analyzed through the proposed method. Statistical significances in the lateral dose profile were observed in the beam energy and full width at half maximum (FWHM) of the radial distribution through Spearman's rho analysis. Although we could find local minimums in the fitted slope curves in univariate analyses, we performed multivariate analyses through logistic regression. As a result, the optimal initial electron beam parameters were determined as 6.5 MeV mean energy with a spread of ±5% and radial intensity distribution of 1 mm FWHM. The calculated dose with the optimal beam parameters was good agreement with the measured dose distributions.

Conclusions: This study has found the optimal initial electron beam parameters for a 6 MV Linac with statistical methods for the first time. The Linac model built with Geant4 in this study can be used for further simulations such as radiation therapy planning or more.

Keywords: Monte Carlo simulation, statistical analysis, logistic regression, commissioning