Development of Water-filled phantom and Comparision film dosimetry for five phantoms in Gamma Knife

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Purpose:

The objective of this study is to investigate the scattering effect of the plastic phantoms by determining FWHM and penumbra from the measurement of absorbed dose profile in Gamma Knife radiosurgery facility using EBT3 GafChromic film and three plastic phantoms and one water-filled spherical phantom.

Materials and Methods:

A spherical shell water-filled phantom with the shell thickness a radius of 4 mm and, a spherical shape Polystyrene plastic phantom and PMMA plastic phantom were developed. The radius of each phantom was determined to be the same as the reference depth of water, 8 g/cm^2, recommended in IAEA TRS-483. From the element analysis of each material followed by electron density calculation, the equivalent water depth (EWD) of Polystyrene corresponding to 8 g/cm^2 water depth was 7.88 cm and that of PMMA was 6.93 cm. Inner phantoms that hold the EBT3 films were designed and produced. A commercial Solid Water Phantom was also used for the measurement of absorbed dose profile. The absorbed dose rate to water was measured with two ionization chambers PTW31010 and Exradin A16. The irradiated films were scanned in TIFF image format using a high-resolution flatbed scanner (EPSON 10000XL) with a transparency unit. The scanned images then were analyzed using appropriate software (Doselab 6.80 Version) to convert the image data into optical density distribution of the film and then to convert the optical density into absorbed energy on the film. For each phantom, the absorbed dose profile was obtained along each axis (X-, Y-, and Z-). FWHM and penumbra (=<d_{20} – d_{80}>, where d_{20} is the distance from the mechanical center to a position at which the intensity is 20% of the center intensity, and d_{80} is to a position of 80% for the ± direction of each coordinate) for each plastic phantom were determined and compared with those of the spherical shell water-filled phantom to obtain the scattering effect of the plastic phantom.

Results:

Comparison of the absorbed dose profile of 20% in the maximum between the plastic phantoms and the Water-filled phantom showed that Solid Water phantom was 3.1%, the Polystyrene was 3.7%, and the PMMA phantom was 5.8% higher than Water-filled phantom. It is the result of x-axis, and the repeated of experiments on y-axis and z-axis showed similar differences. As expected result using the Water-filled phantom, the scattering effect was less than other plastic phantoms.

Conclusions:

The experiments using Water-filled phantom showed more accurate value than the result of using the plastic phantoms. In the future, more efficient and various phantom will be developed.

Keywords:

Gamma Knife, absorbed dose, penumbra, FWHM, dose distribution curve, scattering effect

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