Monte Carlo calculations and GafChromic film measurements for Leksell Gamma Knife unit

Hsiu-Wen Lee[1], Ren-Dih Sheu[2], Uei-Tyng Lin[2], Wei-Li Chen[1]

1. Institute of Radiological Science, National Yang-Ming University, Taipei, TW

2. National Radiation Standard Laboratory, Institute of Nuclear Energy Research, Tao-Yuan, TW

Introduction:

The Leksell Gamma Knife is a standard radiosurgical tool for treating brain lesions by directing beams of gamma radiation to a specific region. The diameter of the gamma beams is confined by collimator systems and the available collimator sizes are 4, 8, 14 and 18 mm. The reduction in dose rate for each collimator helmet is called the output factor. Experimental determination of output factors is difficult due to the extremely narrow beams by which the dose is determined. In the present work, the Monte Carlo technique and GafChromic films were employed to verify the dose distribution and the output factor of Gamma Knife (type B) radiosurgery.

Material and methods:

The Monte Carlo program EGS4 and the user code OMEGA/BEAM were used to calculate the dose distribution along the x, y, and z axes when a single shot with opening of all 201 sources was delivered at the center point (unit center point: x = 100mm, y = 100mm, z = 100mm) of a spherical homogenous polystyrene phantom with a diameter of 160 mm, with gamma angle of 90 degrees. Four different sizes of collimator helmets, 4, 8, 14 and 18 mm, were studied.

The type of the film employed in this experiment was GafChromic MD-55 with CAT.NO. 37-041, produced by Nuclear Associates, which has a measurement range of 3-100 Gy. The reader for GafChromic film was manufactured by Kodak, USA, and was comprised of a He-Ne laser light-sensor density scanner LS-50. The image resolution of the LS-50 laser light-sensor density scanner was 12 bit, and the spatial resolution was set to 0.2mm.The LS-50 laser light-density scanner system was calibrated before each GafChromic film reading.

Results and conclusion:

The output factors measured with GafChromic film and the results of our Monte Carlo trials were within uncertainty range and showed consistency with the value provided by the manufacturer of Leksell Gamma knife, Elekta. Moreover, good agreement in dose profiles along x, y, and z axes for all collimator helmets were summed up over all 201 sources. On the other side, the change in dose distributions can also be predicted by simulation at the interface area. The application of EGS4 Monte Carlo technique is important, because the accurate measurement results may not be obtained easily. It should be included as a part of quality assurance program for the Gamma Knife radiosurgery.