Determination of Beam Quality of High Energy Photons in Non-Standard Reference Condition Using Linear Fit Method

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Abstract

Tissue Phantom Ratio ($TPR_{20,10}$) for the field size of (10 × 10) cm^2 became the beam quality index for most of the code of practice, whereas percentage depth dose (%dd) $(10)_X$ is the beam quality index for the TG-51 code of practice. In the present work, we have proposed a simple linear fit method to determine the beam quality index under non-reference conditions (i.e., radiotherapy treatment machines which cannot simulate a reference condition of 10 × 10 cm^2 field size) that validated using BJR supplement 25 data. $TPR_{20,10}$ versus square filed sizes from (4 × 4) cm^2 to (12 × 12) cm^2 is a linear straight line. By using the data given in the British Journal of Radiology (BJR) Supplement-25, we have plotted a straight line graph for lower field sizes and obtained the beam quality index of the reference field size 10 × 10 cm^2. The calculated $TPR_{20,10}$ by the linear fit method from present studies were also compared and analyzed with Palmans method for the photon beam energy from 4 MV to 25 MV.

Keywords: Beam quality, non-reference condition, small field dosimetry, megavoltage photon beams, linear-fit method

1. Introduction

Upright clinical results of Stereotactic Radiation Therapy (SRT) and Intensity Modulated Radiation Therapy(IMRT) techniques in recent decades introduced dedicated stereotactic treatment machines which cannot reproduce the reference field size (10 × 10) cm^2 conditions for the absolute dosimetry. The increasing uses of SRT and IMRTin the recent years, small field dosimetry became a passionate research topic. $TPR_{20,10}$ for the field size of (10 × 10) cm^2 became the beam quality index for the International Atomic Energy Agency (IAEA), Technical Report Series (TRS) -398 [1] and most of the code of practice, whereas $\%dd(10)_X$ is the beam quality index for the Task Group (TG) report 51 code [2] of practice published by the American Association of Physicists in Medicine (AAPM). Beam quality determination for high energy photon beams for non-reference conditions were extensively studied by Sauer [3] and Palmans [4]. Palmans' proposed equation for the beam quality determination for non-reference condition has been accepted and recommended for the upcoming small field code of practice to be jointly published by IAEA and AAPM.

Kawachi et al. [5] has described that the radiation beam treatment with Cyber-Knife machine, the head and collimator system cannot reproduce the standard conditions of reference dosimetry. Under the above circumstances the reference dosimetry is not possible under uniform conditions. The beam quality correction factor k_Q for ordinary photon beam such as 6 MV is temporally substituted for the k_Q of the Cyber-Knife in many sites.

Kawachiet al. [5] found that if the absorbed dose is measured with ionization chamber with a cavity length of 2.4 cm for 6.0 cm circular collimator then it will underestimate 1.5% in the reference dosimetry.

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The measurement procedure for small fields are not standardized, several authors quoted [6, 7] that unacceptable variation were recorded by the use of standard method which is applicable for larger fields but that are not suitable for the small field where the lateral charge particle equilibrium does not exist. This work, like to propose a simple linear fit method to determine the beam quality index under non-reference conditions using BJR supplement 25 data [8]. This entire research work was carried at the Department of Radiation Oncology, United Hospital, Dhaka, in collaboration with Department of Physics, Jahangirnagar University, Savar, and Secondary Standard Dosimetry Laboratory (SSDL) of Bangladesh Atomic Energy Commission, Savar.

2. Materials and Methods

The $TPR_{20,10}$ for a field size of (10 × 10) cm^2 is commonly used for determination of the beam quality (Q) for high energy photon beams. The reference square field size of 10 × 10 cm^2 is not feasible due to its dedicated design of the stereotactic treatment machines. Generally, $TPR_{20,10}$ versus square filed sizes from (4 × 4) cm^2 to (10 × 10) cm^2 is a linear straight line (Fig.1). Using the BJR data, we have plotted a straight line graph for the square field sizes of 4 × 4 cm^2 to 6 × 6 cm^2 along the x-axis and the $TPR_{20,10}$ for the particular field size along the y-axis for the photon beam energy 4 MV to 25 MV. An equation of $y = mx + c$ was derived from the plotted line, where y is the $TPR_{20,10}$, x is the field size, m represents the gradient and the c represents the 'y' intercept. By substituting x = 10, in the equation we can determine the beam quality of $TPR_{20,10}$ (10). The proposed Linear-fit calculated $TPR_{20,10}$ (10) were compared and analyzed with Palmans method for the photon beam energy from 4 MV to 25 MV. The proposed linear fit model has been experimented for the beam energy 2 MV to 50 MV and compared with the BJR data. We have