REPORTS OF PRACTICAL ONCOLOGY AND RADIOTHERAPY 20 (2015) 170–180

Available online at www.sciencedirect.com

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journal homepage: http://www.elsevier.com/locate/rpor

Original research article

Measurement and comparison of head scatter factor for 7 MV unflattened (FFF) and 6 MV flattened photon beam using indigenously designed columnar mini phantom

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A R T I C L E I N F O

Article history:
Received 19 August 2013
Received in revised form
10 December 2014
Accepted 8 February 2015

Keywords:
Sc factor
7MV-UFB
6MV-FB
Mini phantom
Linear accelerators

A B S T R A C T

Aim: To measure and compare the head scatter factor for 7 MV unflattened and 6 MV flattened photon beam using a home-made designed mini phantom.

Background: The head scatter factor (Sc) is one of the important parameters for MU calculation. There are multiple factors that influence the Sc values, like accelerator head, flattening filter, primary and secondary collimators.

Materials and methods: A columnar mini phantom was designed as recommended by AAPM Task Group 74 with high and low atomic number material for measurement of head scatter factors at 10 cm and d_{max} dose water equivalent thickness.

Results: The Sc values measured with high-Z are higher than the low-Z mini phantoms observed for both 6MV-FB and 7MV-UFB photon energies. Sc values of 7MV-UFB photon beams were smaller than those of the 6MV-FB photon beams (0.6–2.2% (Primus), 0.2–1.4% (Artiste) and 0.6–3.7% (Clinac iX (2300CD))) for field sizes ranging from 10 cm × 10 cm to 40 cm × 40 cm. The SSD had no influence on head scatter for both flattened and unflattened beams. The presence of wedge filters influences the Sc values. The collimator exchange effects showed that the opening of the upper jaw increases Sc irrespective of FF and FFF.

Conclusions: There were significant differences in Sc values measured for 6MV-FB and unflattened 7MV-UFB photon beams over the range of field sizes from 10 cm × 10 cm to 40 cm × 04 cm. Different results were obtained for measurements performed with low-Z and high-Z mini phantoms.

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http://dx.doi.org/10.1016/j.rpor.2015.02.001

1. Background

It is generally considered that the absorbed dose at the point within a phantom can be divided into two components[1–5]: a part due to primary radiation and a second part carried by photons scattered in the treatment head reaching the point of interest. Primary radiation is that photon radiation generated at the source that reaches the patient without any interactions. Scattered radiation (Sc) is that photon radiation with a history of interaction/scattering with the flattening filter, collimators or other structures in the treatment unit head. The direct radiation and scattered radiation comprise the output of radiation, which from the patient's point of view equals the incident radiation. The contribution to the absorbed dose from electrons released by photons scattered from elsewhere in the patient is called the phantom scatter (Sp) component. The basic method for separating scatter radiation (Sc) from Linac head and scatter radiation from phantom (Sp) involves the measurement of the total scatter factor in a phantom (St) and either the head scatter factor (Sc) or the phantom scatter factor (Sp) individually.[1,6,7] A direct measurement of Sp involves complex methods compared to Sc measurements.

The determination of the Sc is usually done by in-air measurements with sufficient material surrounding the detector to prevent contaminating secondary particles from reaching the detector volume and to provide enough charged particles for signal strength. Historically, Sc is measured at depth of maximum dose (d_{max}) with a water equivalent build-up cap and wall thickness equivalent to depth of maximum dose in water phantom. This method suffers from a number of problems, like detector response difference for electrons and photons,[8,9] absence of unique value of d_{max} for different field sizes and source-to-surface (SSD) distance.[10–12] To solve the above problem, AAPM therapy physics committee Task Group 74 (TG74)[13] recommends the build-up caps in cylindrical shapes along with long axis parallel with the beam central axis and the ion chamber placed at 10 g/cm^2 water equivalent depth for Sc measurements. These build-up caps are generally called columnar mini phantoms. The 10 g/cm^2 volume is sufficient to prevent contaminating electrons from reaching the detector.[14] In general, low-Z materials are recommended for mini phantoms. A high-Z mini phantom is used for small field Sc measurements.

In a conventional clinical accelerator, the flattening filter is placed in the photon beamline to compensate for the non-uniformity of photon fluence across the field. This, however, may not be necessary for certain types of treatments. In intensity modulated radiation therapy (IMRT), for example, additional beam modifying devices, such as multileaf collimators (MLCs), are used to modify actual fluence distributions to produce optimal fluence maps.[6,15–20] In principle, the flattening filter can then be removed, and the leaf sequences can be adjusted accordingly to produce fluence distributions similar to those of a beamline with a flattening filter. One of the cutting edge technologies introduced by linear accelerator manufacturers utilizes unflattened high dose rate beams (without flattening filter – up to 2400 MU/min) available for clinical treatment. The flattening filter is a major source of scatter radiation.[21–27] The variation in the characteristics of Sc due to the effect of contaminating electrons, collimator exchange effect, impact of beam modifying devices and the effect of source to detector distance have been extensively studied earlier using mini phantom and build up cap measurement for flattened beam.[5,28–32]

2. Aim

Aim of this study is to measure and compare Sc values of 6MV-FB (flattened) and 7MV-UFB (flattening filter free) photon beams which could be delivered by SIEMENS-ARTISTE linear accelerator (Siemens Medical Systems, USA). The home-made mini phantom was used to study and compare the Sc of three different LINACs, the effect of low and high-Z mini phantoms for various field sizes. Also Sc values were measured at different SSDs with and without beam modifying devices and the effect of collimator exchange of 6MV-FB and 7MV-UFB.

3. Materials and methods

The columnar mini phantoms used for Sc measurements were indigenously constructed using Poly Methyl Metha Acrylate (PMMA), which is a water equivalent polymer material. The chamber insert was 20.0 cm in total length and 3.5 cm in diameter (Fig. 1). The ion chamber was placed at 10 cm water

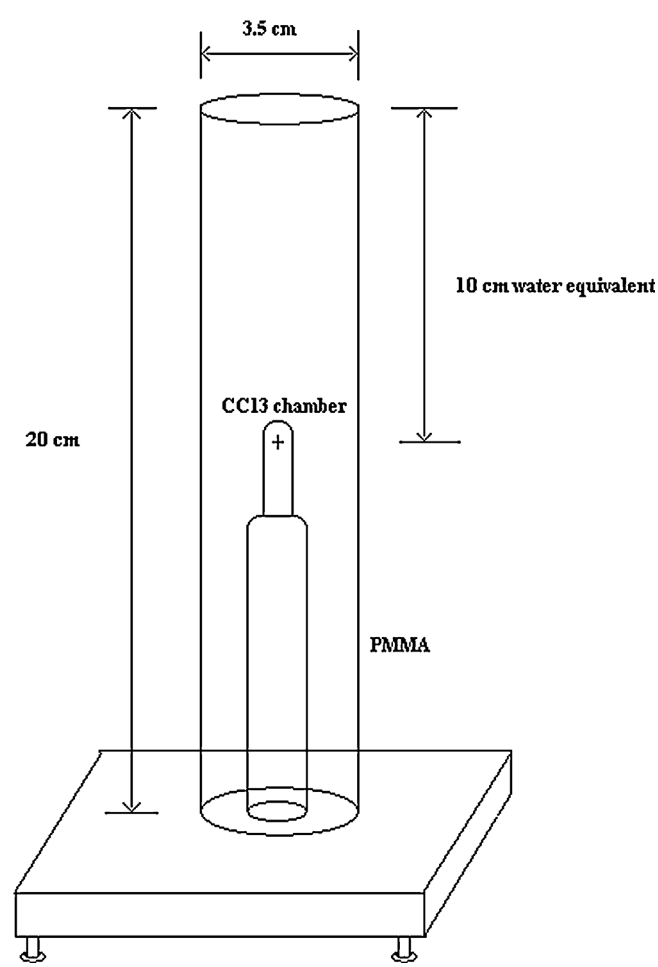

Fig. 1 – Block diagram of PMMA columnar mini phantom.