Ain Shams University
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Dosimetry Study of Physical Parameters for Flattening Filter Free and Standard Photon Beam Energies in Radiotherapy

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A thesis submitted in conformity with the requirement for M.Sc. in Science (Physics - Radiation Physics), Faculty of Women for Arts, Science and Education.

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بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

قُلْ لَوْ كَانَ الْبَحْرُ مِدَادًا لِكَلِمَاتِ رَبِّي لَنَفِدَ الْبَحْرُ قَبْلَ
أَنْ تَنْفَدَ كَلِمَاتُ رَبِّي وَلَوْ جِئْنَا بِمِثْلِهِ مَدَدًا ﴿١٠٩﴾
قُلْ إِنَّمَا أَنَا بَشَرٌ مِثْلُكُمْ يُوحَى إِلَيَّ أَنَّمَا إِلَهُكُمْ
إِلَهٌ وَاحِدٌ فَمَنْ كَانَ يَرْجُو لِقَاءَ رَبِّهِ فَلْيَعْمَلْ عَمَلًا
صَالِحًا وَلَا يُشْرِكْ بِعِبَادَةِ رَبِّهِ أَحَدًا ﴿١١٠﴾

[سورة الكهف]

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Dedicated

To

My parents (Father and Mother),

My brothers,

My wife,

My cognates,

My professors

and

My colleagues

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ABSTRACT

Abstract

Recently started to be used in radiotherapy clinical practice the Flattening filter free (FFF) beams generated by medical linear accelerators. Flattening filter free beam have a fundamental physical parameter differences with respect to the standard filter flattened (FF) beams, making the generally used dosimetric parameters and definitions not always viable.

The current study will propose study for some dosimetric parameters for use in quality assurance of FFF beams generated by medical linacs in radiotherapy.

The main characteristics of the photon beams have been analyzed using specific data generated by a Varian TrueBeam linac having both FFF and FF beams of 6 and 10 MV energy, respectively and MP3 water tank, a large size, remote-controlled To operate the tank, MEPHYSTO version (mc2) control software from PTW for an automatic positioning of the MP3 water tank via stepper motor control and TBA electronics are required and Semiflex Ionization Chambers 31010. The beam was adjusted and the gantry angle was kept at zero degrees and to ensure that the beam was parallel to the central axis; measurements were performed at various depths and various field size.

To investigate the changes in the beam spectrum sample depth dose (DD) curves were measured to compare with standard data we found that there's significant differences between FFF and standard photon beam.

The softer spectra of the flattening filter free beam due to Production of contaminant electrons also affects depth doses beyond d_{max} leads to a steeper drop in dose deposition beyond the depth of maximum dose (d_{max}), also differences due to this are mainly observed in the surface region, show that there is a slight increase in surface dose with the flattening filter removed and we found that the depth-dose depends on the flattening filter, and field size dependence of surface dose is smaller for FFF than FF and the depth of maximum dose shows weak dependence on field size variation for the FFF beam ,depths of dose maxima for flattened and unflattened beams did not deviate by more than 2mm .

Definitions for dose profile parameters are suggested starting from the renormalization of the FFF with respect to the corresponding FF beam. From this point the flatness concept has been translated into one of “unflatness” and other definitions have been proposed, maintaining a strict parallelism between FFF and FF parameter concepts.

Beam profiles of FFF beam differ significantly from the FF beam. The central peak in the beam profiles of FFF beam is pronounced only for medium to large field sizes. The higher energy is the more pronounced in the central peak. We found that outside the treatment field the doses are lower for non-flattened beams due to the reduction in out-of-field scatter. This would effectively act to reduce the dose to surrounding normal tissues.

The shape of the beam profile of a FFF beam changes slightly with depth due to a significantly reduced off-axis softening effect and hence the depth dose characteristic remains almost constant across the field even for large field sizes.

The quality controls used in establishing a quality assurance program when introducing FFF beams into the clinical environment are given here, keeping them similar to those used for standard FF beams and, recommendation for introduction of FFF beams into a clinical radiotherapy application for breast cancer patient as best example for comparison between FFF and FF for good dose distribution and coverage for target volume.

In summary, although there are a number of advantages of using a FFF beam especially for advanced radiotherapy techniques there are a few challenges (e.g., criteria for beam quality evaluation and penumbra, establishment of dosimetry methods, and consequences of photon target burn-up) which need to be addressed for establishing this beam as an alternate to the FF beam.

List of Symbols & Abbreviations

BSF	Backscatter Factor
CAX	Central Axis
CIAO	Complete Irradiation Area Outline
D_{max}	Depth of Maximum Dose
DVH	Dose-Volume Histogram
DMI	Digital Megavolt Imagers
EBRT	External Beam Radiotherapy
EPID	Electronic Portal Imaging Device
IBRT	Internal Beam Radiotherapy
FFF	Flattening Filter Free
FS	Field Size
GR	Gantry Rotation
GA	Gantry Angle
IMRT	Intensity Modulated Radiotherapy
ITP	Inverse Treatment Planning
LINAC	Linear Accelerator
MLC	Multi leaf Collimator
MU	Monitor Unit
OAD	Off-Axis Distance
OAR	Off-Axis Ratio
OAR	Organ at Risk
OF	Output Factor
PDD	Percentage Depth Dose

PDIP	Portal Dose Image Prediction
PTV	Planning Tumor Volume
SAD	Source-Axis Distance
SCD	Source-Collimator Distance
SDD	Source -Diaphragm Distance
SF	Scatter Factor
SSD	Source-Surface Distance
TD	Target Dose
TPS	Treatment Planning System
TV	Target Volume
VMAT	Volumetric Modulated Arc Therapy