Photon beam profile investigation and percentage depth dose (PDD) determination in a dosimetric set-up using Elekta Synergy Linac

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ABSTRACT

The beam profile and percentage depth dose profile (PDD) are vital in delivering a correct and exact dose to a tumor in radiotherapy treatment. These variables are relevant indicators to determine the clinical status of the linear accelerator which can be obtained via a quality assurance procedure. In the quality assurance processes, the researcher aims to determine and investigate the beam profile (flatness and symmetry) and the PDD of the photon beam in water using 6 MV and 10 MV beam energy in a 10 cm by 10 cm radiation field. The investigation utilizes ELEKTA SYNERGY platform linear accelerator, water phantom, and cylindrical ionization chamber. The photon beam profile (flatness and symmetry) was obtained, and the PDD was investigated. It was found that the values of the beam flatness and the beam symmetry of the photon beams indicate an acceptable value based on the recommended acceptance level of the American Association of Physics and Medicine (AAPM). Moreover, the key variable in the PDD of the photon beam which is the beam quality index or tissue-phantom ratio shows an acceptable deviation from the reference value based on the 2% tolerance AAPM standard. Thus, the beam profile obtained using 6 MV and 10 MV photon beams indicates that the ELEKTA SYNERGY platform linear accelerator is capable of delivering an accurate photon beam as determined by the beam profile and PDD.

Finally, the Elekta Synergy platform can still be used in radiotherapy procedures and provide a therapeutic beam with clinical beam quality for a skin-sparing effect, accurate dose delivery to a target volume, and excellent organ at-risk avoidance.

INTRODUCTION

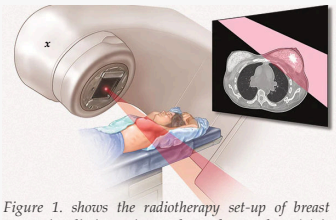

Figure 1. shows the radiotherapy set-up of breast cancer irradiation using a photon beam where (x) is the Linac (Image taken from Mayo Foundation for Medical Education and Research).

To Achieve the Goal of The Radiotherapy Treatment:

"One must ensure that the Linac produces a therapeutic beam"

HOW?

Via determination of the Dosimetric characteristics of the Beam (e.g., Beam Flatness, Beam symmetry), including percentage depth-dose.

THROUGH?

QUALITY ASSURANCE TEST

Radiotherapy Treatment Procedure

Goal, *[1-2]:*

- *Produce an accurate beam with an excellent target margin*
- *Deliver a correct and exact dose to the tumor*
- *Optimize the potential to spare healthy tissue*

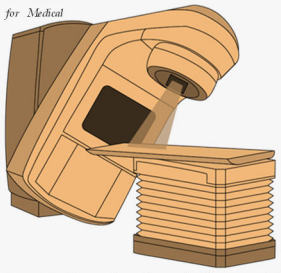

Figure 2. shows the schematic diagram of the radiotherapy setup showing the beam source, movable table, imaging system, and the beam

METHODS

QUALITY ASSURANCE SETUP

QUALITY ASSURANCE PROCEDURE

QUALITY ASSURANCE TEST

Investigate/ Determine the DOSIMETRIC CHARACTERISTICS

EVALUATE BEAM PROFILE (Flatness and Symmetry) and the PDD

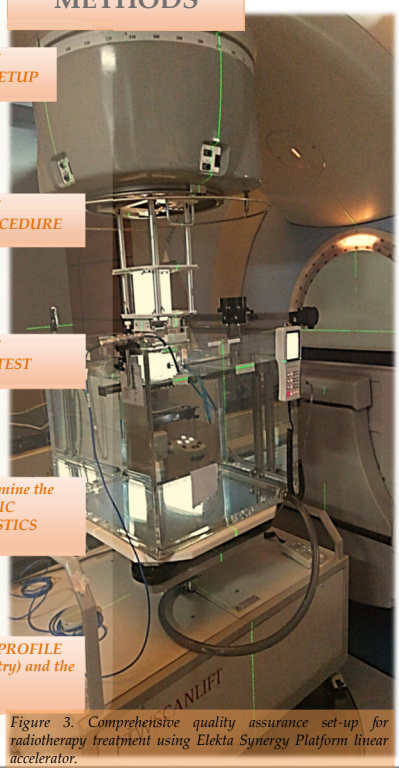

Figure 3. Comprehensive quality assurance set-up for radiotherapy treatment using Elekta Synergy Platform linear accelerator.

RESULTS AND DISCUSSION

Table 1 shows the characteristic profile of the 6 MV photon beam using 10 cm x 10 cm field size at various depth

6 MV				
Depth	In-Plane		Cross-Plane	
cm	Flatness (%)	Symmetry (%)	Flatness (%)	Symmetry (%)
1.70	102.98	102.05	101.84	101.29
10.00	104.91	102.38	104.36	102.27
30.00	107.15	103.06	106.67	101.14

Table 2 shows the characteristic profile of the 6 MV photon beam using 10 cm x 10 cm field size at various depth

10 MV				
Depth	In-Plane		Cross-Plane	
cm	Flatness (%)	Symmetry (%)	Flatness (%)	Symmetry (%)
2.30	102.5	100.44	102.62	101.42
10.00	103.25	100.52	104.48	101.25
30.00	104.63	100.4	105.72	101.2

- *Beam Flatness increases with depth both in 6 MV and 10 MV incident Photon beams, as shown in Table 1 and Table 2.*
- *The values fall within the standard reference values of 103% ± 5% set by the European Society for Therapeutic Radiology and Oncology (ESTRO) and the American Association of Physicists in Medicine AAPM codes of practice.*
- *The Beam Symmetry of the photon beam must remain within the 103% acceptance level set by ESTRO and AAPM [2].*
- *All the values of beam symmetry, both in 6 MV and 10 MV, are within the 103 % acceptance value, as shown in Table 1 and Table 2, except for 6 MV at a depth of 30 cm in-plane values.*

- *Table 3 and Table 4 revealed that the values of D_{100} and D_{200} increases with increasing incident photon beam energy.*
- *The beam quality index (BQI) is a significant variable that determines if the beam is clinical or not, with a standard range value of BQI is 0.5 to 0.78 [3-4].*
- *Table 3 and Table 4 show an acceptable range value of BQI in 6 MV and 10 MV incident photon beams which is 0.6770 to 0.6836.*
- *BQI or TPR20,10 (Tissue-Phantom Ratio20,10) is the ratio of the dose on the central axis located at 20 cm depth in a water phantom to the dose in the central axis located at 10 cm depth.*

Table 3 shows the absorbed dose in water normalized to the maximum dose, which is clinically known as Photon Percentage Depth Dose (PDD), using a 6 MV photon beam.

6 MV			
Quantity	Reference	Measured	Remarks
R100 (mm)	16.99	17.03	0.24%
D100 (%)	68.49	68.3	0.28%
D200 (%)	39.86	40.09	0.58%
BQI	0.677	0.6836	0.97%

Table 4 shows the absorbed dose in water normalized to the maximum dose, which is clinically known as Photon Percentage Depth Dose (PDD), using a 10 MV photon beam.

10 MV			
Quantity	Reference	Measured	Remarks
R100 (mm)	23.98	23.6	1.58%
D100 (%)	73.41	73.25	0.22%
D200 (%)	45.91	45.89	0.04%
BQI	0.7337	0.7351	0.20%

Beam homogeneity or field flatness and symmetry are considered the quality determining factor of photon beams delivered from linear accelerators [4-6].

In this investigation, it was seen that the values of beam flatness and beam symmetry in 6 MV and 10 MV incident photon beam is within the acceptable standard level. This implies Elekta Synergy platform can deliver accurate doses to the target volume. Moreover, the photon percentage depth dose profile indicates that the beam delivered by the Elekta synergy platform Linac still matches the machine's specifications.

In addition, the data shows that as the energy increases, the depth of the maximum dose also increases, which further means that the skin-sparing potential of the beam delivery is excellent.

Furthermore, the value of the maximum dose (D_{100}) increases as the energy of the photon beam increases. The increase in the dose-value is due to the increase of electron contamination in the build-up region.

Finally, this investigation can be extended to the determination of the beam profile characteristics of photon and electron beams using various field sizes for designing optimized treatment plan.

SUMMARY

The value of the beam flatness, beam symmetry, and PDD has been determined, which indicates that the Elekta Synergy platform linear accelerator could deliver a clinically therapeutic beam using 6 MV and 10 MV incident photons. However, this investigation can be extended using various field sizes to track the isolated case of the beam symmetry in 6 MV at a depth of 30 cm in-plane.

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