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Assessment of Mechanical Accuracy of Cobalt-60 Teletherapy Unit at SSDL, Bangladesh Atomic Energy Commission

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ABSTRACT

As the rate of death due to cancer is increasing in the world, the world is paying much more attention to effective treatments for cancer. Teletherapy is a type of treatment that delivers radiation to cancer cells from a specific distance. The focus of this study is exclusively on Cobalt-60 teletherapy, which has recently been installed at the Secondary Standard Dosimetry Laboratory (SSDL) of the Bangladesh Atomic Energy Commission to provide quality assurance and quality control services for all radiotherapy machines in Bangladesh. Our objective is to conduct a series of measurements that are necessary for the commissioning and acceptance of the installed Cobalt-60 machine (Equinox 100). The measurements include some mechanical parameters, including the accuracy of a variety of indicators and the size of the fields, before the measurement of dosimetry with two protocols, TRS-277 and TRS-398. We have found 0.16% deviation in the accuracy of optical indicator, 0.04% deviation in the accuracy of collimator angle indicator and 0.06% deviation in the accuracy of field sizes throughout the study. We have found no error in the accuracy of gantry indicator. In this work, the focus is primarily on the mechanical calibration to ensure that a dosimetry plan that is practical and accurate is being developed for the treatment of cancer patients. The output of this study may contribute to the development of treatment planning systems for cancer treatment.

1. INTRODUCTION

In the present world, cancer is becoming one of the most critical illnesses in the human body. According to IAEA estimates, cancer is the cause of almost 13% of deaths worldwide and more than 10 million individuals are diagnosed with cancer each year [1]. Several years earlier, it was predicted by academics that approximately 20 million new cases of cancer were expected throughout the world in 2020; those new cases would mostly affect the population in developing countries [2]. Though cancer was considered a Western disease, now cancer is affecting and killing more people in the developing world than in industrialized nations [3].

There are mainly three well-established areas in the management of cancer in modern medical science: surgery, chemotherapy, and radiation therapy [4]. Among these three, radiation therapy is more prominent than the rest. Because around 50% of cancer patients in the world are treated by radiation therapy both curatively and palliatively [5]. The treatment of cancer especially radiation therapy was not same throughout the recent years. Before the ionizing particle (charged or uncharged) beams were introduced, the field of medicine had limited options for the treatment of cancer [6].

An important fact is that this radiation therapy can be delivered to the tumor through two processes: external beam radiation therapy (EBRT) or brachytherapy [7]. Usually, EBRT is a local treatment, which means that it gives treatment to a specific part of the human body. For example, if a patient has cancer in the lung, he/she will get radiation only to his/her chest in EBRT, not to his/her whole body [8]. Brachytherapy is a specific form of radiation therapy used to treat cancer. It consists of placing sealed, radioactive sources directly into or next to the tumor to be treated, either directly or by means of catheters. Brachytherapy can be used either alone or in combination with EBRT to increase the dose focally in advanced primary tumors requiring high doses to be cured, such as cervical cancer or prostate cancer [9].

The therapeutic treatment of cancer refers to the use of ionizing radiation for destroying malignant cells. However, the actual purpose of destroying the tumor cells is to protect the vital cells from infections [10],[11]. In today's world, Cobalt-60 teletherapy machines are the cheapest among all the external-beam radiotherapy machine available in the realm of cancer treatment. Besides being comparatively cheap, the Cobalt-60 teletherapy machine has some other advantages such as low maintenance cost, lower power need, less machine downtime, constancy of beam quality, etc. Due to these reasons, Cobalt-60 machines are suitable for the treatment of commonly encountered types of cancers in LMICs (Lower Middle-Income Countries) [12].

The main principle of a Secondary Standard Dosimetry Laboratory (SSDL) is to bridge the gap between the Primary Standard Dosimetry Laboratory (PSDL) and the users of ionizing radiation by enabling the transfer of dosimeter calibrations from the primary standard to the user instrument [13]. One of the principle goals of SSDL, Bangladesh (situated at Ganakbari, Savar, Dhaka) in the field of radiotherapy dosimetry is to ensure that the dose delivered to patients undergoing radiotherapy treatment is within internationally accepted levels of accuracy [14]. According to ICRU, the delivered dose should be within ±5% of the prescribed dose [15].

The standards for radiation oncology prescribed by the American College of Radiology [16-18], specify a QA program including patient chart review [19-24].

The aim of the work is to evaluate the mechanical accuracy of the Cobalt-60 Teletherapy unit which is used in this study. Which is useful in determining several dosimetric parameters throughout the radioactive exposure. In the next section (Section 2) we have discussed about the materials and method. In Section 3, we have presented the results of our study and the remaining section outlines the conclusions of our work (Section 4).

2. MATERALS AND METHODS

The Secondary Standard Dosimetry Laboratory (SSDL) of the Bangladesh Atomic Energy Commission (BAEC) is facilitated with well-equipped dosimetry and radiation safety equipment. Cobalt-60 teletherapy machine under trade name EQUINOX-100 with teletherapy source number S-6356, source type Cobalt-60 (Co-60), and a maximum capacity of source head equal to 445.0 TBq (12,026 Ci) supplied by Best Theratronix Ltd., was used in this study.

Gamma-ray spectra from Co-60 therapy sources used at hospitals or SSDLs have a substantial component of low-energy scattered photons, originating in the source itself or the treatment head, but ionization chamber measurements are not expected to be influenced by ^{60}Co spectral differences by more than a few tenths of one percent [25]. For this reason, ^{60}Co gamma rays for radiotherapy dosimetry do not require a beam quality specifier other than the radionuclide. The measurement of dose (output) for SSD (source to surface distance) techniques is done by following the TRS-398 protocol for absorbed dose measurement in External Beam Radiotherapy (EBRT).

The specific requirements on equipment according to TRS-398 [14] follow closely the requirements in TRS-277 [26], TRS-381 [27], and the IEC standards 60731 [28] for dosimeters with ionization chambers

Two water phantoms were used in the dosimetry. One dimensional IAEA phantom (30 cm × 30 cm × 30 cm) was used for dose calculation and a two dimensional CNMC phantom (40 cm × 38 cm × 38 cm) was used for measurement of PDD (Percentage Depth Dose) and Beam Profile. They both were also used in determining several indicators in the mechanical investigation.

Before going to the dosimetry part, it's very important to check various mechanical parameters regarding the Co-60 teletherapy unit. For ensuring the accuracy of mechanical parameters, some crucial checks (Table 1) like the parameters of optical field size verifications, the accuracy of alignment lasers, optical distance indicator (ODI) accuracy, mechanical isocenter concerning the rotation of gantry and collimators, collimator and gantry angle accuracy, parallelism and orthogonality of jaws, movements of the couch (treatment table) in various directions, etc. were performed for their specified tolerance prescribed by IAEA.

The calibrated Farmer chamber (FC65-G #4324) was placed at the reference depth of 10 cm in the 30×30×30 cm^3 water phantom. For SSD measurements the surface of water was kept at 100 cm, such that source to chamber distance was 110 cm. Then five readings were taken each for 1 minute for different field sizes ranging from 4×4 cm^2 to 43×43 cm^2. There are some other pieces of equipment those were used throughout the procedure.

3. RESULTS AND DISCUSSIONS

3.1 Various checks and observations for the machine during the installation process

The following checks were performed to ascertain the functional integrity of the machine where the cobalt source is driven pneumatically for exposure.

The various functional parameters for a Co-60 teletherapy unit during the installing process are shown in Table 1.

Table 1: Functional parameters for a ^{60}Co teletherapy machine

Procedure	Measured value/ finding	Status
Operational parameter	Checked	Functional
Door interlock	Checked	Functional
Emergency off	Checked	Functional
Radiation room monitor	Checked	Functional
Audiovisual monitor	Checked	Functional

3.2 Accuracy of optical indicator

The accuracy of optical indicator of Cobalt-60 teletherapy unit is given in Fig. 1.

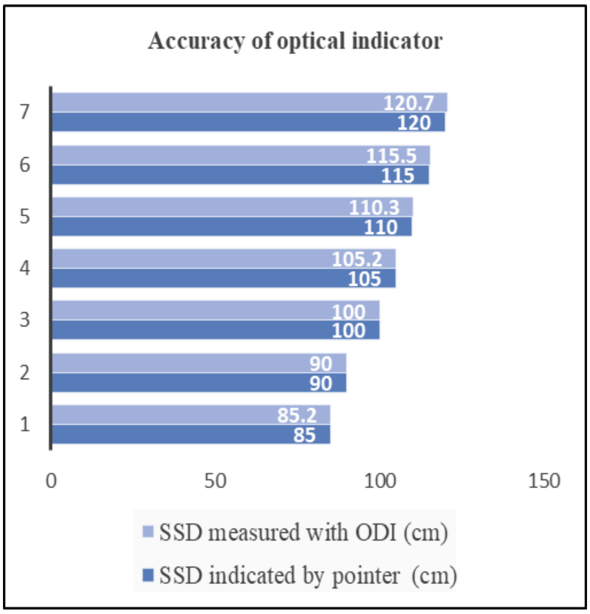

Fig. 1: Accuracy of optical indicator

According to Fig. 1, the estimated deviation in the accuracy of optical indicator is 0.16%.

3.3 Accuracy of gantry indicator

The accuracy of gantry indicator is shown in Fig. 2.

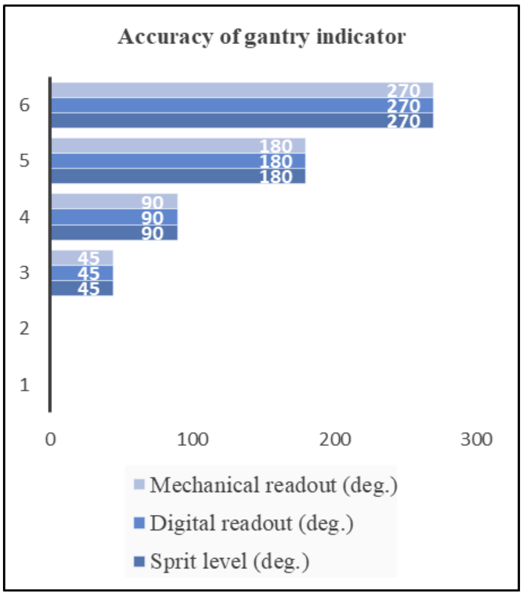

Fig. 2: Accuracy of gantry indicator

According to Fig. 2, there is absolutely no deviation in the accuracy of gantry angle which leads to the maximum level of acceptance in the investigation.

3.4 Accuracy of collimator angle indicator

The accuracy of collimator angle indicator is shown in Fig. 3.

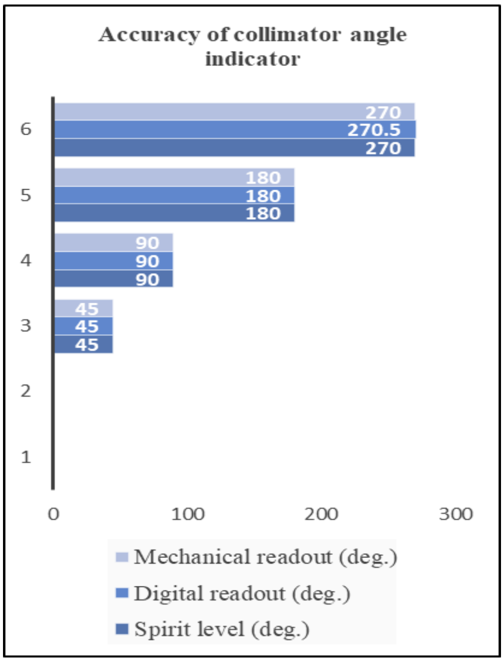

Fig. 3: Accuracy of collimator angle indicator

According to Fig. 3, the estimated deviation in the accuracy of collimator angle indicator is 0.04%.

3.5 Accuracy of field sizes

The accuracy of field sizes is given in Table 2.

Table 2: Test for accuracy of field sizes

Dial setting field sizes (cm × cm)	Measured light field X (for lower jaw) (cm)	Measured light field Y (for upper jaw) (cm)	Deviation for lower jaw (cm)	Deviation for upper jaw (cm)
4 × 4	4	4	0	0
5 × 5	5	5	0	0
10 × 10	10	10	0	0
15 × 15	15	15	0	0
20 × 20	20	20	0	0
25 × 25	25	25	0	0
30 × 30	30	30	0	0
35 × 35	35.1	34.9	0.1	-0.1
43 × 43	43	43	0	0

According to Table 2, the estimated deviation in the accuracy of field sizes is 0.06%.

The accuracy of the treatment of a cancer patient depends greatly on the precision of the measurement of the different mechanical parameters of the Cobalt-60 teletherapy unit. In the analysis of mechanical accuracy prior to the radioactive exposure and dosimetry procedure, some small deviations were observed. These deviations might have occurred due to mechanical errors in the teletherapy unit, errors in positioning the chambers, etc. In general, the deviations in some of the measurements of this work were within acceptable limits.

5. CONCLUSION

According to research, around 2 lakh patients are newly diagnosed with cancer each year in Bangladesh. The radiotherapy treatment of this significant number of cancer patients is performed by several cancer hospitals with several equipment. The accuracy of this radiotherapy treatment depends on several factors; one of them is mechanical accuracy in the calibration of the equipment. SSDL, Bangladesh Atomic Energy Commission provides this calibration facility to the cancer hospitals in Bangladesh. We have found a 0.16% deviation in the accuracy of the optical indicator, a 0.04% deviation in the accuracy of the collimator angle indicator, and a 0.06% deviation in the accuracy of field sizes. We have found no error in the accuracy of the gantry indicator. According to this study, the newly installed Cobaly-60 teletherapy unit has a very small deviation in mechanical accuracy and may provide the maximum possible accuracy in the dosimetric level and area monitoring process. Hence, this study may contribute to ensuring accuracy in the treatment of cancer in Bangladesh.

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CONFLICT OF INTEREST

The authors have confirmed that there is no conflict of interest with this work.

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