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Research Article

In-Vivo Dosimetry with Diode for the Treatment of Pelvic Malagnancies

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Abstract

The ±3% overall tolerance limit in absorbed radiation dose delivery has been recommended by The International Commission of Radiological Units (ICRU). *In-Vivo* Dosimetry (IVD) is one of the best Quality Assurance (QA) tool to check the dose delivered to the patients being treated with radiation. The aim of the current investigation is to check the diode IVD system to measure the entrance and exit dose in radiation therapy for pelvic malignancies during treatment and its implementation as a patient-specific QA tool for the verification of the dose delivery. During February 2014 to December 2015, the entrance & exit dose of 254 pelvic patients have been measured using diode IVD system and compared these with calculated corresponding values. Totally 1,614 radiation fields have been monitored. The analysis of data showed the percentage Δ±0.083% with α ±2.179% between measured and prescribed dose. It was observed that 99.814% measurements using diode remained within the action level i.e. within ±5% and 86.493% within ±3%. Larger deviations have been observed in lateral and wedged fields as compared to anterior-posterior fields. The positioning of patients and diode has been noticed as the common source of errors for variation, alone or in combination with other sources. The measurements repeated after the rectification of error(s), were found within action level. The current investigation revealed that diode IVD is simple, cost effective, offers immediate outcomes and can function as a suitable patient specific-quality assurance tool in radiotherapy.

Keywords: *In-vivo* Dosimetry; Diode; Pelvis; Radiation Therapy; Co-60

Introduction

Cancer, possibly more than any other term, has the impact to make one's blood run cold. It is a cruel killer, and nearly nothing can block its path once it has spread. Regardless of our technologies and developments, our research institutes, and myriad researchers devoted to eradicate the cause, cancer remains an actual threat. Pelvic cancer is the common malignancy. It is anticipated that almost 22.2 million new cancer cases will be noticed yearly over the world by 2030 [1]. Radiotherapy is needed for the treatment of 80% cancer patients [2,3]. Radiation therapy is an effective treatment modality for both palliative and curative treatment of cancer along with surgery and chemotherapy.

The local tumor control depends on the accurate delivery of radiation dose to patients being treated with radiation therapy. The ±3% overall tolerance limit in absorbed radiation dose delivery in radiation therapy has been recommended by ICRU [4,5]. IVD is the key technique to assure the exact dose delivery during radiation therapy to a patient [6]. Entrance dose measurements verify the patient set-up, the radiation output, and performance of the radiation equipment. Exit dose measurements additionally verify the dose calculation algorithm and determine the effect of various factors like the contour of the treatment portal, patient's thickness and tissue in-homogeneities and calculation of absorbed dose for radiation therapy of cancer patient [7-11]. The diodes and thermoluminescent dosimeters are the most common detectors being used for IVD [8-10,12,13]. Metal oxide semiconductor[8], alanine/gel [14,15], plastic scintillators [16,17], Presage dosimeter [18], radiochromic films [19] and conventional portal films or electronic portal imaging devices [20] are other detectors being used for dose verification in clinical radiation therapy practice. The preference for particular detector influenced by various aspects, for example, type of measurement, training of the radiation personnel, cost, personal preference and availability (key factor) [21]. Although it is recommended by various international organizations [9,10,22-26] for routine verification of the dose delivery for all groups of patients undergoing radiotherapy but IVD is rarely used in our country for routine verification of absorbed radiation dose in clinical radiation oncology practice [2].

This investigation was performed to check the utilization of diode IVD for *in vivo* verification of entrance & exit dose in radiation therapy for pelvic (prostate, bladder, rectum and cervix) malignancies being treated in our institute and comparison with the calculated values of the absorbed dose for corresponding radiation portals.

Materials and Methods

Entrance & exit dose for patients undergoing pelvic (prostate, rectum, cervix, endometrium and urinary-bladder cancers) radiation therapy on Co-60 photons beam has been measured using diode IVD system. The Co-60 photons beam has been calibrated using an ionization chamber (TN30013-03936 PTW, Freiburg, Germany) positioned at 5cm depth in water phantom according to IAEA TRS-398 protocol [27]. The IVD system used in this study consisted of

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Figure 1: Different portals of pelvis patient with diode dosimeter fixed in the center of radiation field.

PDM Model No. 37-721 and ISORAD n-type diode Model No. 117009 (Nuclear Associates, NY, USA). The detailed characterization of diode IVD system has been performed as per procedure outlined in the literature [2]. The action level is set ±5% for pelvic patients initially for the period of six months and then it has been decided to lower down the action level to ±3%. The diode has been positioned onto the skin of the patient in center of the radiation field as shown in the figure 1. All fields have been monitored in first week of treatment. Entrance dose has been calculated at a depth of 0.5cm from entrance surface. Exit dose has been calculated at a depth of 0.5cm from beam exit point. Entrance & exit dose has been calculated as per procedure outlined in the literature [8].

Results

The diode has been calibrated for entrance/exit absorbed dose verification in Co-60 beam under reference conditions. The mean entrance calibration factor was 1.516 (SD 0.0089, N=43) and the mean exit calibration factor was 1.938 (SD 0.0196, N=43).

From February 2014 to December 2015, two hundred and fifty four (254) patients have been monitored that are treated on Co-60 radiation therapy machine. One thousand, six hundred and fourteen (1,614) radiation fields were measured using diode dosimeter and compared with the calculated values of the corresponding radiation portals. The analysis of all available measurements showed a mean percent deviation of ±0.083% with standard deviation (SD) of ±2.179%. The detail results are presented in (Table 1). It was witnessed

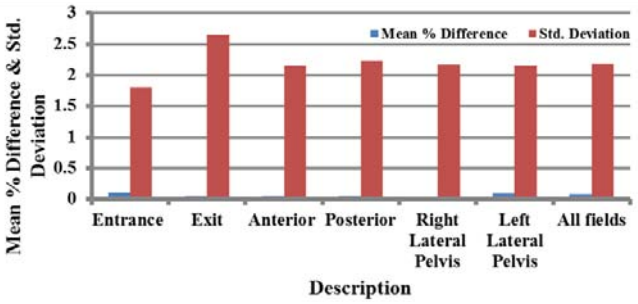

Figure 2: Comparison of results among different treatment portals.

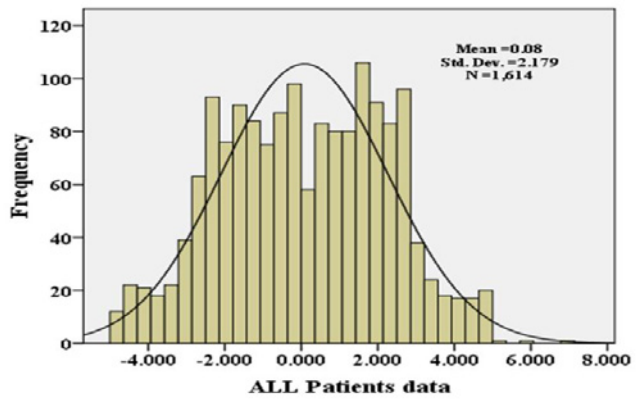

Figure 3: Histogram of results between calculated and diode measured doses.

that 99.814% of our results remained within action levels, i.e. within ±5% (an action level for initial six months of study) and 86.493% within ±3% (an action level set for remaining period of study). Only 215 (13%) measurements out of 1,614 were noticed outside ±3%, 201 out of 215 (99% of 215) measurements were observed during initial period of study.

Comparison among different treatment fields is depicted in the figure 2. The frequency distribution (histogram) of results between the measured and calculated dose for different treatment portals is presented in the figure 3.

Discussion

The present study for performing IVD in clinical radiation oncology using diode detector to measure entrance & exit dose for patient being treated in our institute revealed accuracy within

Table 1: Results for *in-vivo* dose verification for pelvis cancer patients.

Description	Number of Measurements (N)	% of Measurements (N) Within |Δ| ≤±3 %	% of Measurements (N) For (±3% ≤|Δ| ≤ ±5%)	% of Measurements (N) Within |Δ| ≤±5 %
Entrance	971	97.734	1.96	0.31
Exit	643	69.518	30.48	0
Anterior	461	85.466	14.53	0
Posterior	443	84.65	14.67	0.68
Right Lateral Pelvis	355	89.296	10.7	0
Left Lateral Pelvis	355	87.324	12.68	0
All Fields	1614	86.493	13.32	0.186

permissible limit as recommended by the ICRU [4,5]. The outcomes of this study not only provided self-confidence that the absorbed dose of radiation was delivered as planned (patients were being treated as per prescribed dose); at the same time other mistakes/errors were noticed as well and were corrected. The main advantages of diode includes small size, bias less, cost-effectiveness and the immediate results that can facilitates the rectification of variations observed (if any and necessary too),even though the patient was on the treatment couch or during following fractions.The analysis of all available measurements showed a mean percent deviation of ±0.083% with SD of ±2.179%. It was seen that 99.814% of our results remained within action levels, i.e. within ±5% (an action level for initial six months of study) and 86.493% within ±3% (an action level set for remaining period of study. The outcome of the treatment could be compromised, if intended dose is not delivered and that further signifies the importance of IVD during patient treatment in any radiation therapy center. The overexposure case observed in Scotland is the most recent incident reported [28] and it will be avoided if *in-vivo* system was in place.

It has been observed that 3 (0.186% of 1,614) measurements were above ±5% difference and 215 (13.321% of 1,614) measurements were above ±3% variation between calculated and diode measured dose. In posterior fields, the fixation of diode was a challenging task; it may be the cause of greater mean percentage difference. The correct fixation of the dosimeter was the most significant in wedged field as well. Our results are comparable to the literature [2,8,10,11,29,30].

The action level is ±5% for pelvis fields for preliminary period of six month and then lowered to ±3%. Two hundred and fifteen (215) measurements have been noticed with $\Delta \geq \pm 5\%$. Out of these, 201 (19 entrance, 196 exit) measurements were >±5%, were considered acceptable since these were observed in initial period of study when action level was ±5%. Fourteen (14) out of two hundred and fifteen (215) measurements have been noticed when action level is ±3%. In six (6) out of these fourteen (14) fields, inaccurate SSD was the cause of higher Δ and in other eight (8) measurements; incorrect dose is the cause of higher Δ as repeated measurements after the rectification of said problems were within tolerance. For larger variations, the position of both the patient and diode has been observed to be common error alone or in grouping with other factors. Measurements have been repeated after rectification and doses were found within tolerance level. In ten (10) measurements the diode was detached from the posterior surface and these has been repeated in the next fraction.

Although significant work has been done for dose verification using diode but this does not lessen the significance of IVD in clinical radiation oncology as recent over exposure case [28] could be avoided using IVD. The current study presents the results of large cohort of pelvic patients that were treated with Cobalt-60 photons beam.

Conclusions

This investigation revealed that diodes clinical dosimetry system is a useful QA tool for verification of dose delivery and in identifying the systematic/random errors. It has enhanced the quality of radiation dose delivery and reliability of the system. In this investigation, two hundred and fifty four (254) pelvis patients are monitored. One thousand, six hundred and fourteen (1,614) radiation fields are measured using diode dosimeter and compared with the calculated values. The analysis of results showed that a mean percent deviation Δ of ±0.083% and standard deviation (σ) of ±2.179% which is comparable to the most published results. A higher incidence of errors might happen due to overlooked systematic errors having no IVD program in clinic. To start the IVD program as a QA, various requirements are needed to be fulfilled and especially it alarmed the whole system and all the contributing personnel in radiotherapy become more conscious about quality keeping in mind the accountability and this resulted in quality enhancements of the treatment given.

Acknowledgement

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Conflict of Interest

We (Mr. Muhammad Asghar Gadhi, Dr. Saeed Ahmad Buzdar, and Dr. Shahab Fatmi) hereby certify that regarding this paper, there is no present or potential conflict of interest; the work is original, has not been accepted for publication, nor is concurrently under consideration elsewhere, and will not be published elsewhere without the permission of the editor and that all the authors have contributed directly to the planning, execution or analysis of the work reported or to the writing of the paper.

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