IOSR Journal of Applied Physics (IOSR-JAP)
e-ISSN: 2278-4861.Volume 10, Issue 2 Ver. I (Mar. – Apr. 2018), PP 55-59
www.iosrjournals.org

Measure the Errors of Treatment Set-Ups of Prostate Cancer Patient Using Electronic Portal Imaging Device (EPID)

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Abstract : *The purpose of this work was the determination of the set-up errors for Prostate cancer patients by using electronic portal imaging device (EPID) [14], as tool to verify the patient treatment positioning. This could be done by the means of identifying and correcting the field displacements in patient's setups which requires accurate patient positioning with reference to the initial three-dimension conformal radiotherapy (3DCRT). Patient setup is controlled by comparing the Digitally reconstructed radiographs (DRR) with portal images acquired immediately before patient treatment. It is generally accepted that two classes of set-up uncertainties identified by systematic and random errors. A study on 15th prostate cancer patients using Varian Linear accelerator model DMX to treat and portal image device Si500 shall be used to evaluate the selected portal images taken for each patient. A comparison has been made between previous publish work and new approach of this study. The calculation of PTV margins according to three formulas used in the study, the margins which are calculated according to ICRU Report 62 is suggested as an optimum margin for target volume coverage which is <5 mm in all three directions. This study using an electronic portal imaging device (EPID) to measure the set-up deviations μ for Prostate cancer patients and calculate the set-up errors Σ set-up and σ set-up and, for my Department of Medical Physics in my hospital to find the optimal correction strategy to decrease μ.*

Keywords: *Prostate Cancer; 3D conformal radiation therapy; EPID; Radiotherapy; CT Image; ICRU (50&60)*

Date of Submission: 03-03-2018 Date of acceptance: 19-03-2018

I. Introduction

Prostate cancer is now the most common cancer in men, and the second most common cause of cancer related death in men. The uncertainties in the daily set-up of the Prostate cancer patients during the treatment can give rise to the complications the results of the treatment. Those Set-up errors (uncertainties) can be reduced by repositioning of the patient according to the set-up verification. According to this, protocol for repositioning of the patients is chosen. Each radiotherapy center should have in place site specific verification protocols that are tailored to the needs of that site and consider the factors affecting the accuracy of set-up error include the site treated, the immobilization used and the patient's condition.

1- Systematic and Random errors [12]:

a- Systematic errors in radiotherapy, the term systematic error may be used when referring to the individual patient, or to the treatment population. Which are reproducible, consistent errors, occurring in the same direction and of similar magnitude. These may occur at the start of radiotherapy or during the course of treatment.

b- Random error in radiotherapy, is always present in a measurement. Random errors show up as different results for the same repeated measurement. Random errors can also arise from changes in target position, and shape, between fractions and during treatment delivery.

II. Experimental Work

The aim of this study is to extract quantitative data from direct measurements of patient's set-up errors for Prostate cancer patients, using an electronic portal imaging device (EPID) to define adequate treatment margins. 15th Prostate cancer patients were treated as patient group with 3DCRT, in period of time between Dec 2016 and Dec 2017 were considered in this study. Patients are immobilized and treated in the supine position with a comfortably full bladder and after rectal voiding on a solid flat carbon fiber couch top. Immobilization systems using a head pad combined with individually adjustable knee and ankle supports provides a high degree of accuracy without the need for further pelvic immobilization with anterior and lateral laser lights to align midline and lateral skin tattoos to prevent lateral rotation. Linear accelerator–Varian model DMX–high energy

(dual energies 6.0 and 15 MV) photon beam and multi electron energies (6.0, 9.0, 12, and 15 MeV) has been used as treatment device. Treatment planning system 'Eclipse' also, used in this work. Electronic portal Image Device (EPID) vision aS500 will be used as verification Device, which was amorphous silicon based EPID system consisting of a detector screen and optical chain. It was mounted iso-centrically on the Linear Accelerator with a detector size of 30×40 cm.

III. Experimental Measurements

Radiotherapy was given 2 Gy per Fraction, 5 fractions per week, 35-38 fractions to total dose 70-76 Gy. The patients were treated with high energy photons (15 MV) on Varian Medical linear accelerator (Model DMX) treated with 3D Conformal RT 5 beams techniques, Beams with customized MLC shielding are chosen to include the PTV and minimize the dose to the OAR, a dose distribution is calculated. show Fig. (1). The dose distribution for different fixed 5 fields technique is suitable for covering the PTV by 95% isodose lines.

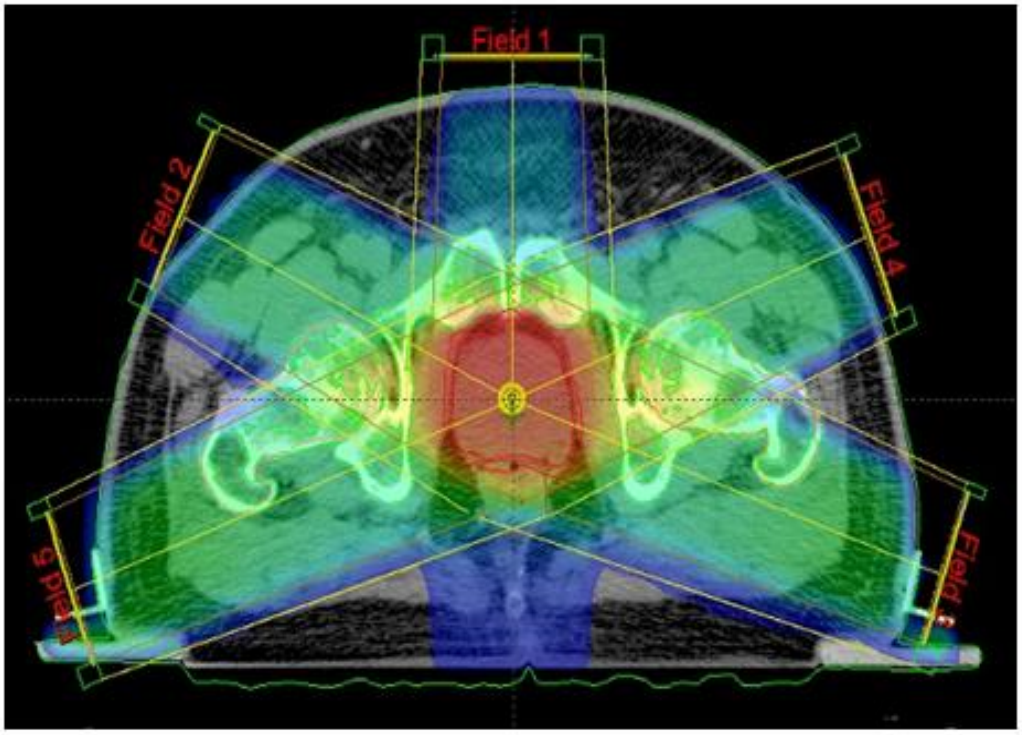


Figure (1), The Axial view for 3DCRT plan using 5 fields' arrangement

IV. Verification and Evaluation Protocol

Pre-treatment electronic portal images are obtained for the first day of treatment [6] and first day of each week by using Electronic portal image device with average of 10 paired images per each patient at orthogonal gantry angles 0˚ and 90˚ using a typical exposure time 1 MU at a dose rate of 300 MU/min and 15 MV X-ray energy. The obtained portal images compared with DRRs produced by the treatment planning system, using reference marks such as identifiable bony landmarks of the treatment field which measured in three major directions. For documentation and analysis, anterior, superior, and right sided shifts are coded as positive shifts and posterior, inferior and left-sided shifts as negative shifts. The difference between EPID and DRR Images are estimated along three major directions by anatomical match structure that they fall within the treatment filed chosen. Using bony anatomy with EPI for verification of the patient's position provides no information regarding the soft tissue as shown in Fig. (2).

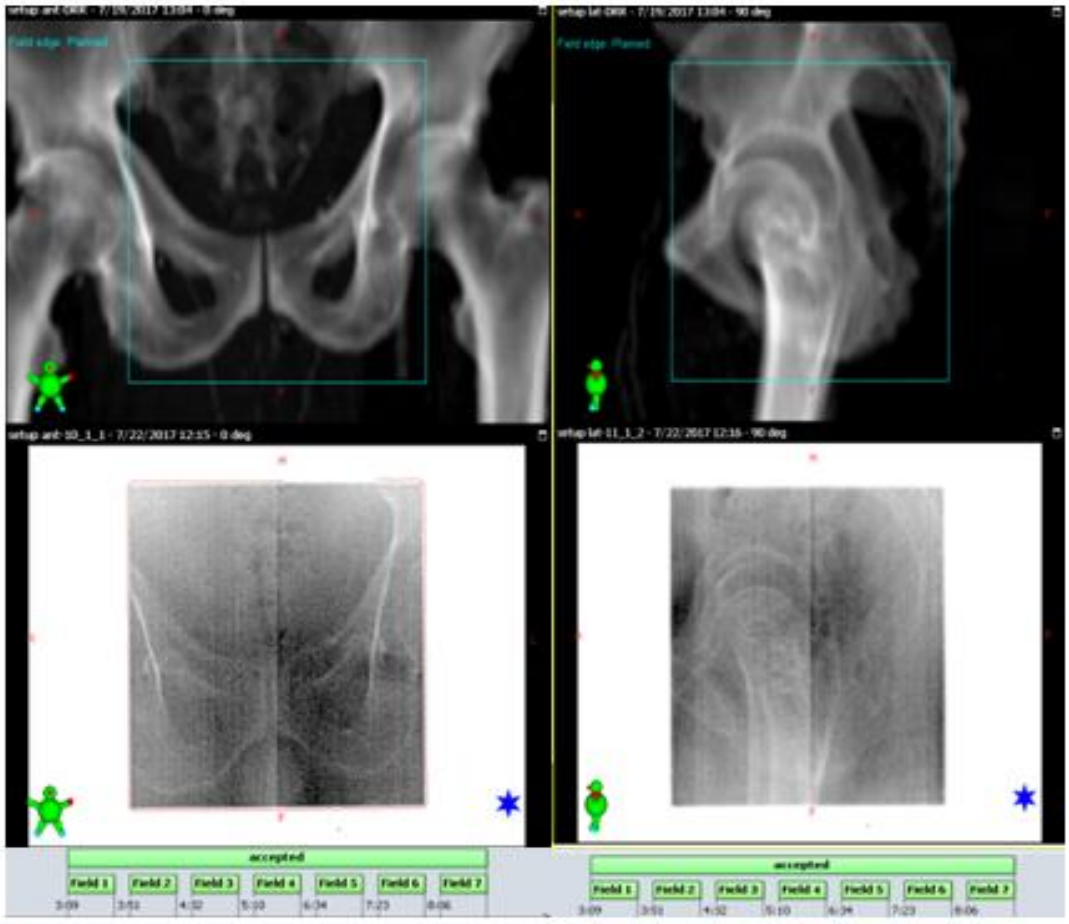


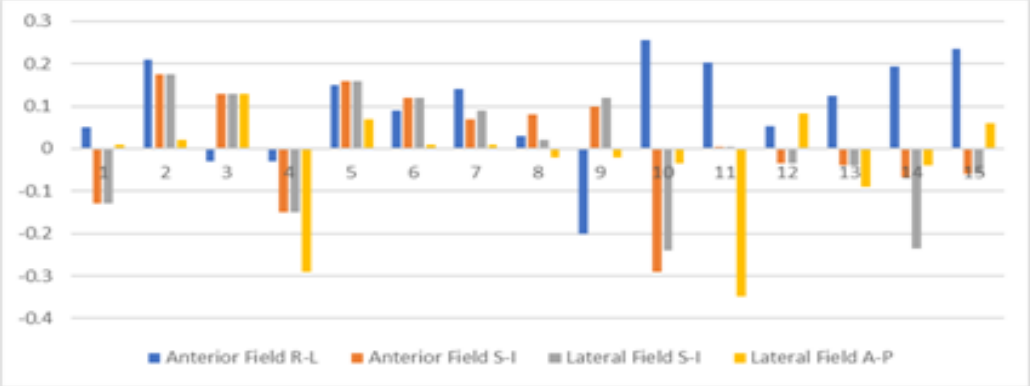
Fig.(2), The DRR for Anterior and Right Lateral Views for Prostate patient

According data analysis for matching between standard DDRs for prostate patient were included current work and portal image taken during all sessions for each case. The displacement data was used to estimate and analyses population systematic (Σ) and random errors (σ) and set-up margins. Mean displacements, population systematic (Σ) and random errors (σ) and set-up margins are calculated using published margin recipes; International Commission on Radiation Units and measurements (ICRU) report 62 = (√Σ 2 +σ 2) [3], Stroom (2Σ+0.7σ) [6,7] and van Herk (2.5Σ+0.7σ) [8,9]. The Microsoft office Excel software 2016 are used to analyze and calculate the setup errors variations. The mean displacements, systematic and random errors in Prostate cancer patientsthat measured and estimated in vertical, longitudinal and lateral directions. The mean displacement using bony anatomy in the pelvis and no correction expected to be in the range of 2-5 mm depending on site and size of treatment field, as show in the Table (1) and Fig. (3-4).

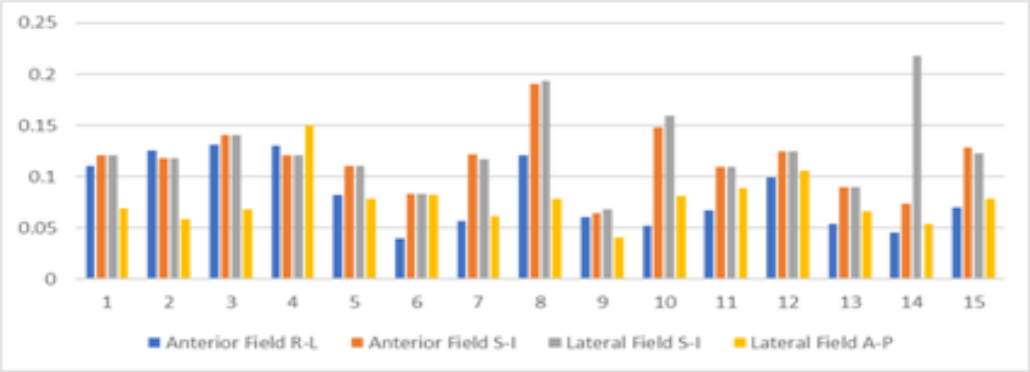
	Anterior Field		Lateral Field	
	R-I	S-I	S-I	R-L
Overall Mean M_{ave}	0.0982	0.00467	-0.00467	-0.03
Systematic Error $\sum_{ave}$	0.0268	0.02	0.0239	0.035
Random Error σ_{ave}	0.083	0.116	0.126	0.078

Table (1),overall mean and set-up errors for Prostate cancer along three major axes.

In Table (1), It is observed that, there is a significant difference in displacements for major three axes. Approximately 75 % of displacements are within the tolerance uncertainties.



Fig, (3) The Population mean set-up variation for 15 patients



Fig, (4) The Random Errors set-up variation for 15 patients

We will show the importance of reducing the geometric uncertainty with respect to the size of the CTV- PTV margin. By measuring the day- to- day variation in the position of the Tumour, the systematic and random uncertainty in that position can be determined Averaging these data for several patients will allow the assessment of the margin for a group of Prostate cancer patients. A large CTV- PTV margin will result in a large dose in organs at risk and will limit the dose that can be given to the PTV. The use of a treatment verification protocol to control set-up errors may be used to reduce currently applied margin. Several mathematical formulae have been recommended for generating CTV-PTV margins. The ICRU 62 assumes that random and systematic errors have an equal effect on dose distribution, which may not necessarily be the case. Using coverage probability matrices and dose-population histograms, Stroom et al .2002, Van Herk et al 2003 have suggested formulae which incorporate this differential effect. The Calculation the CTV to PTV margins according to ICRU Report 62, Stroom and van Herk's formulae are given in Table, (2).

Direction	ICRU-62 SM= $\sqrt{\Sigma^2+\sigma^2}$	Stroom formula SM=2Σ+0.7σ	Van Herk formula SM=2.5Σ+0.7σ
R-L (ANT)	0.088	0.111	0.125
S-I (ANT)	0.118	0.121	0.131
S-I (LAT)	0.129	0.136	0.148
A-P (LAT)	0.085	0.125	0.141

Table (2), CTV-PTV margins for Prostate cancer

Among Calculated CTV PTV margins according to three formulae Table (2), the margins which are calculated according to ICRU Report 62 is suggested as an optimum margin for target volume coverage.

V. Conclusion

Significant geometric uncertainties are observed for the prostate cancer patients. Therefore, these patient groups require to apply some verification guidelines that help to achieve good set-up accuracy like, Patient positioning should include a knee cushion and ankle support. Setting the isocenter height from the couch top is a more accurate method of setting the isocenter than using skin marks. Attention to rectal volume both at planning and during treatment delivery is important which is the main factors that effect in prostate movement which can be 10-11 mm in the anterior posterior direction and up to 13.1 mm superiorly the use of a rectal balloon in prostate cancer treatment avoids the daily variations in volume of the rectum. The bladder filling has important role in prostate movement and will affect in Dose volume histogram DVH. CT slice thickness should be <3mm. CT/MRI fusion is recommended to aid prostate delineation IV contrast should be used if treating whole pelvis to assist in outlining the nodal target. Re-planning may be required during treatment if systematic errors due to rotations, not easily corrected for by couch shift. Random errors due to rotations or deformation may require larger CTV to PTV margins and on-line IGRT. Offline correction is very effective in managing the systematic component of set-up errors but has little effect on the random component and complete removal of both systematic and random errors can be achieved by on-line position verification.Since it is a logical and feasible extension of all EPI protocols giving significant advantages that far outweigh the disadvantages. Finally, the verification images should be taken avoiding exposing dose critical structures where possible, by reducing the

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IOSR Journal of Applied Physics (IOSR-JAP) (IOSR-JAP) is UGC approved Journal with Sl. No. 5010, Journal no. 49054.

M.Ali Morsy " Measure the Errors of Treatment Set-Ups of Prostate Cancer Patient Using Electronic Portal Imaging Device (EPID." IOSR Journal of Applied Physics (IOSR-JAP) , vol. 10, no. 2, 2018, pp. 55-59.