VACUUM AND THERMOPLASTIC MOULD-BASED IMMOBILIZATION SYSTEMS USED IN PATIENT UNDERGOING PELVIC RADIATION THERAPY: A COMPARATIVE STUDY

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ABSTRACT

Introduction: The aim of the present study was to compare two immobilization systems for comparison of setup errors in targeted radiotherapy. Methods: Retrospective analysis was done for the patients undergoing radiotherapy from May 2012 to December 2018 at our institution. Immobilization was performed on 30 patients sessions (Vacuum cushion i.e., Vac-Lok™ = 15; Thermoplastic mould i.e., Pelvicast pelvic masks = 15). A total of 763 cone-beams were analysed. The target lesion location was verified by cone-beam computed tomography (CBCT) prior to each session, with displacements assessed by CBCT simulation prior to each treatment session. Systematic setup errors, random setup errors, isocenter deviations in the Medio-lateral (ML), Supero-inferior (SI), Antero-posterior (AP), Rotation (yaw) directions of the patient position was calculated. Results: On comparing the Vac-Lok™ and Pelvicast pelvic masks group with respect to Systematic and random error in the lateral, longitudinal, vertical and YAW direction, no statistically significant difference was seen except the random error in YAW direction (P=0.037, Unpaired t-test). There was no difference observed in comparing the isocentric deviation. Conclusion: It was inferred and concluded that using a vacuum cushion for pelvic radiotherapy provides no added benefit compared to using a thermoplastic mould. Thermoplastic mould is recommended for patients receiving pelvic radiotherapy to improve overall reproducibility.

Keywords: Rotational therapy; Radiotherapy; Systematic, random error; Thermoplastic mould; Vacuum cushion.

INTRODUCTION

Radiotherapy aims at controlled killing of tumour cells without harming the surrounding normal tissue. This aims is can be achieved when the daily treatment delivery is accurate and reproducible [1,2]. Effective immobilization has been shown to minimize the variations in positioning and improve outcome of treatment [3-6]. Various immobilization instruments are now available, which improve the immobilization.

The effectiveness of these systems was evaluated by portal imaging which gives two dimensional (2D) information. The 2D information does not provide the error in rotational setup. With the advent of incorporation of CT in radiotherapy, the three-dimensional (3D) information can verified. These systems include the integration of cone beam CT (CBCT) in a linear accelerator. The superiority of 3D information provided by CBCT as compared to 2D information provide by portal images has been observed [7].

The CBCT verification system helps in evaluation of setup accuracy by generating systematic as well as random errors of treatment. The aim of Present study was to measure and the systematic setup errors (Σ), random setup errors (σ), isocenter deviations in the Medio-lateral (ML), Supero-inferior (SI), Antero-posterior (AP), Rotation (yaw) directions of the patient position of the Vac-Lok™ (Vaccum based immobilization system) and Pelvicast pelvic masks (Thermoplastic Mould) groups of patients.

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MATERIAL AND METHODOLOGY

Retrospective data of 30 patients with pelvic malignancies posted for radiotherapy during the period of May 2012 to December 2019 were included. Pelvic patients who are positioned supine are treated using the Vac-Lok™ and Pelvicast pelvic masks with Knee rest immobilizing devices

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Two (2) groups (Vac-Lok™ and Pelvicast pelvic masks) of 15 pelvic cancer patients each, who were treated supine with image guided radiotherapy, were selected randomly. Both groups of patients were selected from the patients treated on one of three linear accelerators (linac), which had weekly mechanical quality control (QC). All patients had pre-treatment verifications on the treatment machine in which a CBCT was taken to compare with the planning simulation. Both were approved by the radiation oncologist managing the patient. The digital readouts of the daily treatment position of the couch were recorded for each patient as the absolute X (ML or lateral), Y (AP or longitudinal), and Z (SI or vertical) and Yaw position of the couch from the record and verify system interfaced to the treatment machine.

A total of 763 (388 for the Vac-Lok™ and 375 for the Pelvicast pelvic masks patient group) daily treatment setup positions were recorded in terms of the X, Y and Z coordinates. The daily translational setup deviation of the patient was calculated by taking the difference

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Table 1. Calculated systematic & Random displacement, and Isocentric deviation for Vac-Lok™ and Pelvicast pelvic masks.

	Over all Mean setup error ± Systematic				**Over all Mean random error ± Random error**				**Isocentric deviation (Mean±SD)**
	Vrt (cm)	Lng (cm)	Lat (cm)	Yaw (deg)	Vrt (cm)	Lng (cm)	Lat (cm)	Yaw (deg)	
Vac-Lok™	0.02±0.14	-0.07±0.46	-0.03±0.25	0.21±0.68	0.36±0.29	0.54±0.24	0.45±0.22	0.56±0.28	0.43±0.34
Pelvicast pelvic masks	0.01±0.16	-0.06±0.38	-0.03±0.20	0.06±0.67	0.29±0.18	0.64±0.23	0.45±0.1	0.72±0.18	0.43±0.15
P value*	0.42	0.47	0.23	0.2	0.21	0.12	0.45	0.037	0.5

Vrt, vertical; Lng, longitudinal; Lat, lateral; Yaw, roll rotation;*Unpaired t test **Vac-Lok™** vs Pelvicast pelvic masks.

between the planned (approved) and daily treatment setup positions in each direction. Each patient's systematic setup error (*mi*) and the population mean setup deviation (*M*), was calculated. Random (**σ**) and systematic (**Σ**) setup errors were then calculated for each group in each direction [8-12]. Average systematic error (**Σ**) is calculated by taking mean of setup errors of all fractions for X, Y and Z coordinates, respectively, during the treatment. The Random (**σ**) setup error is the standard deviation of respective variation of each fraction around the systematic mean. The 3D vector (isocentric deviation) is the resultant displacement in three dimensional spaces from the reference position [3,4,13].

It is calculated as:

$$\text{3D vector} = \sqrt{[(\text{lateral deviation})^2 + (\text{longitudinal deviation})^2 + (\text{vertical deviation})^2]}$$

RESULTS

Table no. 1 shows the mean displacement in lateral, longitudinal, vertical and YAW direction. The population systematic error (**S**pop) of Vac-Lok™ patients in lateral, longitudinal, vertical and YAW direction was 0.14cm, 0.46cm, 0.25cm and 0.6° respectively. The population systematic error (**S**pop) of Pelvicast pelvic masks patients lateral, longitudinal, vertical and YAW direction 0.16cm, 0.38cm, 0.20cm, and 0.6°, respectively. The population random errors of Vac-Lok™ patients lateral, longitudinal, vertical and YAW direction 0.36cm, 0.54cm, 0.44 cm, and 0.5°, while that of Pelvicast pelvic masks patients was respectively 0.29cm, 0.64cm, 0.45cm, and 0.7°.

On comparing the Vac-Lok™ and Pelvicast pelvic masks group with respect to Systematic and random error in the lateral, longitudinal, vertical and YAW direction, no statistically significant difference was seen except the random error in YAW direction (P=0.037, Unpaired t test). There was no difference observed on comparing the isocentric deviation.

DISCUSSION

Setup errors are unavoidable part of routine fractionated radiotherapy are are more common is pelvic malignancies as compared to any other site [14]. These errors not only change the doses delivery but also negate the dosimetric benefit of highly conformal treatment modalities [15-17]. It may also lead to poorer cure rate [18,19]. Hence, it is important to study the setup errors in clinical practice of radiotherapy.

In the present study, the comparison between Vac-Lok™ and Mould group with respect to Systematic and random error in the lateral, longitudinal, vertical and YAW direction showed no statistically significant difference except the random error in YAW direction (P=0.037, Unpaired t test). There was no difference observed on comparing the isocentric deviation.

Song et al. reported no difference in errors recorded when four immobilization systems were compared [20].

Aggarwal A etal found no added benefit when vacuum cushion was compared with 6-clamped Thermoplastic mould for pelvic radiotherapy [21]. In a study by Cheng KF, comparison was done with respect to treatment of radiotherapy of various regions. Of these, the immobilization systems for pelvis showed similar errors [22].

Saini G reported improvement in precision in lateral and vertical direction, while thermoplastic mould was better with respect to longitudinal direction [23].

The findings of the above mentioned studies are similar to those found in the present study. Use of the Vacuum cushion or thermoplastic mould may be selected based on the other factors like comfort, availability and cost.

CONCLUSION

Use of Vac-Lok™ for pelvic RT has no added benefit with respect to the setup errors when compared to pelvicast. Use of these immobilization techniques may be based on other factors of convenience.

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