On-treatment imaging for breast irradiation: evaluating accuracy using MV vs. kV techniques

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On-treatment imaging for breast irradiation: Evaluating accuracy using MV vs. kV techniques

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Introduction

Modern breast radiotherapy has evolved from simple tangential whole breast approaches to more sophisticated techniques utilizing IMRT and VMAT necessitating robust treatment verification. National guidelines outlined in On-Target[1] do not address specific imaging techniques for IMRT and VMAT treatment techniques. The more recent NRIG image-guided radiotherapy report[2] stipulates tangential imaging can only demonstrate error in the plane of the image and not in the 3 cardinal directions, with no further guidance on imaging techniques.

Objectives

The objectives of the investigation were to investigate the level of accuracy achievable using 2D MV tangential imaging compared with 2D paired orthogonal kV imaging for verification of breast set-up errors, and to establish the range of practice for on-treatment imaging for breast radiotherapy across UK and international institutions.

Methods

A quantitative, repeated measures experimental design was employed for data collection. A phantom was customized with an external breast form and radio-opaque wire to simulate a radiotherapy boost volume. The phantom was positioned in a series of thirty simulated setup errors in the antero-posterior (AP), supero-inferior (SI) and right-left (RL) directions. MV tangent and orthogonal kV images were acquired and the accuracy of the imaging modalities tested by comparison of the setup error measurements made on the MV and kV images. The MV tangent images were matched as per institutional protocol. The kV images were matched using the bony anatomy, with the delineated tumour bed used for guidance. Intra-observer reliability was assessed. The overall population setup error and population systematic error were calculated. An online survey was distributed to two UK national radiotherapy special interest groups to ascertain imaging practices for breast radiotherapy on-treatment imaging.

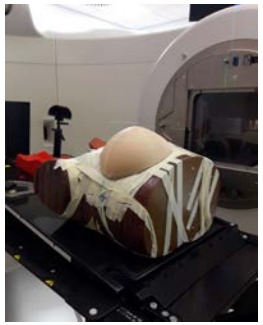

Figure 1: Phantomwith breast form set up for imaging at linac

Results

Intra-observer reliability assessment results demonstrated a strong correlation (r=0.999) indicating validity of the image match results. The difference in mean systematic errors between MV and KV evaluations for AP 0.492cm (95% CI 0.38 to 0.6) SI 0.03cm, (95% CI -0.63 to 0.09) RL 1.02cm (95% CL 0.69 to 1.35) demonstrated a statistically significant improved accuracy for kV compared to MV imaging in the AP and RL directions only. The survey identified similar imaging practices for standard tangential breast radiotherapy, national guidelines were not adhered to and imaging practices varied for complex breast radiotherapy treatment techniques.

	MV AP (cm)	MV SI (cm)	MV RL (cm)	KV AP (cm)	KV SI (cm)	KV RL (cm)
Overall Population Mean Error	0.83	0.29	1.52	0.48	0.13	0.19
Population Systematic Error	0.633	0.116	1.11	0.141	0.09	0.09

Table 1: Overall population mean and population systematic error (cm)

	AP	SI	RL
Difference in means	0.492	0.03	1.02
95% Confidence Interval	0.38 to 0.6	-0.03 to 0.09	0.69 to 1.35

Table 2: Difference in means of systematic error for kV and MV, with corresponding 95% confidence intervals

Conclusions

MV planar imaging was found to be inaccurate in identifying setup error in AP and RL directions and inappropriate to base treatment corrections. The survey demonstrated similar imaging practices for standard breast radiotherapy however guidelines regarding imaging protocols for complex treatments and image registration parameters were generally not adhered to. National guidelines should be revised to reflect current advanced breast treatment techniques.

References

1. On Target: ensuring geometric accuracy in radiotherapy.
1. National Radiotherapy Implementation Group Report: IGRT Guidance for implementation and use.