A service evaluation of 2D planar vs 3D volumetric on- treatment verification for radiotherapy to the upper gastrointestinal tract; is kV planar imaging sufficient to meet plan objectives in this patient group?

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Introduction and Objectives

On-treatment verification using image-guided radiotherapy (IGRT) techniques is fundamental in upper GI radiotherapy for ensuring treatment accuracy. IGRT verification strategies may include 2D kV planar imaging and 3D kV volumetric cone-beam computed tomography (CBCT) imaging but the required frequency of these techniques is under debate (1). There is currently no national UK imaging standard in upper GI radiotherapy; therefore this study aimed to assess the validity of these two imaging modalities for the correction of patient set-up errors.

The two main research questions evaluated were;

1. Are there significant differences between 2D planar bony anatomy and 3D volumetric soft tissue matching in upper GI on-treatment verification?

2. Do the differences have a dosimetric impact on treatment plan objectives and therefore warrant daily 3D volumetric imaging with soft tissue matching?

Methods

Fifty radical upper GI patients who received their full course of radiotherapy/chemoradiotherapy at the Trust within an 18 month timeframe were randomly selected (middle third n=10, lower third n=24, GOJ/Stomach n=16). Region of interest (ROI) boxes on 150 CBCT images stored in ARIA were retrospectively analysed; focusing on 3 match comparisons (see figure 1).

- ***Delta_i:*** Bone and PTV online vs Bone and PTV offline
- ***Delta_ii:*** Bone and PTV vs Bone only
- ***Delta_iii:*** Bone and PTV vs PTV only

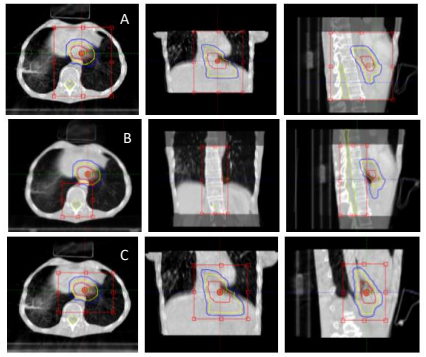

Figure 1. The three ROI boxes analysed; bone and PTV, bone only and PTV only (A-C respectively).

Discrepancies between the automatic matches in the vertical, longitudinal and lateral parameters and anatomical distinctions were reported and a dosimetric assessment using dose volume histograms (DVHs) on the Eclipse planning system was conducted.

Results and Discussion

- There is minimal variability between bone matches performed online clinically and those conducted offline by the researcher supporting the reliability of study findings (table 1 and figure 2).
- The greatest difference in patient set-up error correction between a bone and soft tissue match occurred in the longitudinal direction and in patients with tumours of the lower oesophagus and GOJ/stomach (table 1 and figure 2).
- There is a slight positive correlation between the magnitudes of soft tissue shifts away from bone as patients progress through treatment.
- Only a small percentage of patients required a re-plan or change to daily CBCT imaging during their treatment course.
- Only 14% of the overall study cohort had a mean systematic difference in couch shifts between a bone and soft tissue match of +/-0.3cm or greater over the course of treatment.
- A pilot dosimetry assessment showed that even in the 'worst-case' mean systematic difference reported between a bone and soft tissue match, a bone match was sufficient to meet plan objectives.

Parameter	Mean Delta_i ± SD	Mean Delta_ii ± SD	Mean Delta_iii ± SD
Vertical	0.01 ± 0.05	0.00 ± 0.05	0.04 ± 0.14
Longitudinal	0.01 ± 0.13	-0.01 ± 0.05	0.01 ± 0.31
Lateral	-0.01 ± 0.06	-0.01 ± 0.04	0.02 ± 0.10

Table 1. Mean daily shifts and standard deviations (SD) for all 50 patients in match comparisons Delta_i, Delta_ii and Delta_iii.

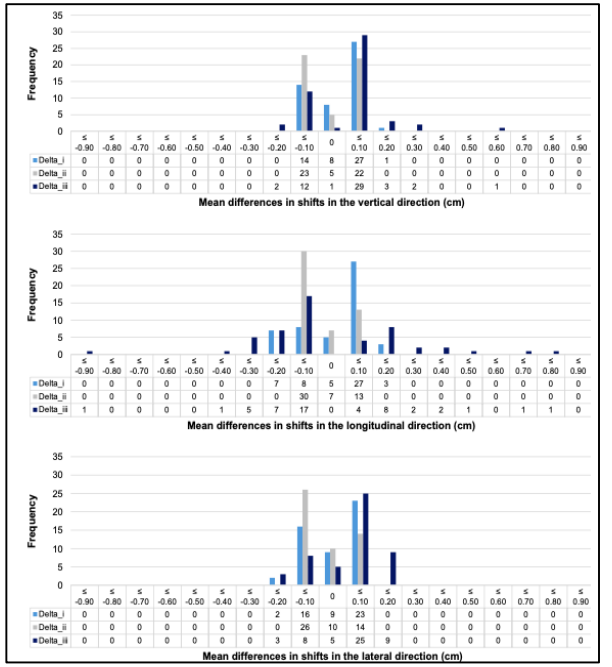

Figure 2. The mean differences in couch shifts in match comparisons Delta_i, Delta_ii and Delta_iii in the vertical, longitudinal and lateral directions and their frequencies.

Conclusions

The fundamental value of kV CBCT imaging for providing imperative soft tissue detail in upper GI on-treatment verification is widely accepted however, the evidence indicates that the greater concomitant dose burden that comes with this imaging modality may not be justified for daily use in this patient group if not deemed essential. kV 2D planar imaging is a simple and accurate alternative method for correcting patient set-up errors that can be conducted with a reduced dose to the patient and should be considered in the optimisation of imaging protocols to ensure on-treatment verification is effectively achieved with radiation dose as low as reasonably practicable.

References

1. The Royal College of Radiologists, Institute of Physics and Engineering in Medicine, The Society and College of Radiographers. *On Target 2: updated guidance for image-guided radiotherapy*. 2021. Available from: https://www.rcr.ac.uk/sites/default/files/radiotherapy-board-on-target-2-updated-guidance-image-guided-radiotherapy.pdf [Accessed 4th March 2022].