A measure of the Target Reposition Errors for Lung VMAT as Observed on CBCT

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Background and Objective

Delivering volumetric arc therapy (VMAT) to lung tumours is challenging due to their susceptibility to movement and change in position from planning to treatment. To be able to compensate for such changes, it is essential for these to be measured. This research set out to measure the department-specific setup errors and tumour reposition errors (TRE) i.e., the shift in position of the tumour in relation to the surrounding anatomy.

Materials and Methods

- 20 patients who had previously completed a course of conventionally fractionated VMAT to the lung between December 2018 and November 2019 were recruited for this study.
- Each participant had a planning CT scan using a Siemens Somaton scanner, and a VMAT plan was created using Elekta Monaco TPS. A cone beam CT (CBCT) was acquired prior to each treatment using Elekta XVI software, resulting in 432 CBCTs.
- An automatic bone match was first performed to obtain the setup error. Then, a further manual match was applied to achieve a GTV match. The values obtained from the bone match were subtracted from those of the GTV match to obtain the TRE.
- From these values, the mean, systematic and random errors were obtained for the individual participants and the population according to RCR (2008) guidelines.
- The individual and population error patterns were also analysed to understand whether an alternative imaging frequency may be used.

Tumour Location	Tumour Size (cm^3)	Fixed or Floating
RUL: 50% RLL: 13% LUL: 23% LLL: 14%	64.90 ± 97.19	Fixed: 81.8% Floating :18.2%

Table 1 Summary of tumour characteristics that may affect TREs. RUL: right upper lobe, RLL: right lower lobe, LUL: left upper lobe, LLL: left lower lobe

	x-axis	y-axis	z-axis
(+)	Left	Superior	Anterior
(-)	Right	Inferior	Posterior

Table 2 Legend for error directions

Results and Discussion

- A systematic posterior setup error of 0.36cm was found (see table 3). It is recommended that the source of this error is investigated. Other than this, the setup errors are comparable to those obtained by other studies that made use of more complex immobilisation techniques.
- The TREs (see table 4) were found to be very small and also comparable to previous similar studies. The left-right TREs were the smallest while the anterior-posterior and superior-inferior TREs were similar. After comparing the results to previous studies concerning SBRT the researchers are confident that more advanced techniques can be considered for this department.
- 51.3% of all treatment fractions had total errors that exceeded the 0.5cm departmental tolerance. Reducing the IGRT frequency was not found to be feasible due to the randomness of daily errors (See Figure 1).

	x	y	Z
Mean ± SD	-0.04±0.26	-0.02±0.34	-0.38±0.26
∑	0.26	0.34	0.26
σ	0.23	0.28	0.23

Table 3 Summary of population total errors (cm). ∑ = systematic error, σ = random error, x = left-right, y = sup-inf, z = ant-post

	x	y	z
Mean ± SD	0.00 ± 0.29	-0.02 ± 0.31	-0.36 ± 0.22
∑	0.29	0.31	0.22
σ	0.26	0.27	0.18

Table 4 Summary of population setup errors (cm). ∑ = systematic error, σ = random error, x = left-right, y = sup-inf, z = ant-post

	x	y	z
Mean ± SD	-0.04 ± 0.09	0.01 ± 0.21	-0.02 ± 0.17
∑	0.09	0.21	0.17
σ	0.08	0.12	0.15

Table 5 Summary of population TREs (cm). ∑ = systematic error, σ = random error, x = left-right, y = sup-inf, z = ant-post

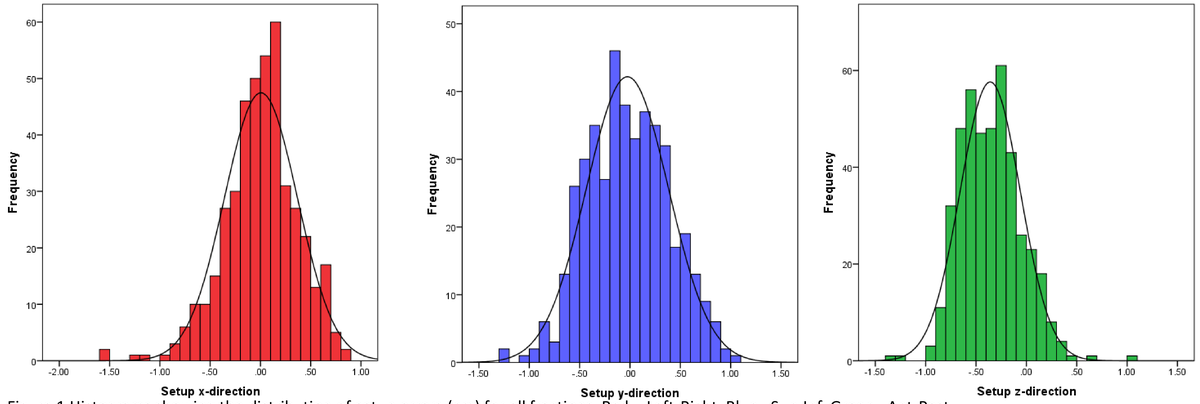

Figure 1 Histograms showing the distribution of setup errors (cm) for all fractions. Red = Left-Right, Blue= Sup-Inf, Green= Ant-Post

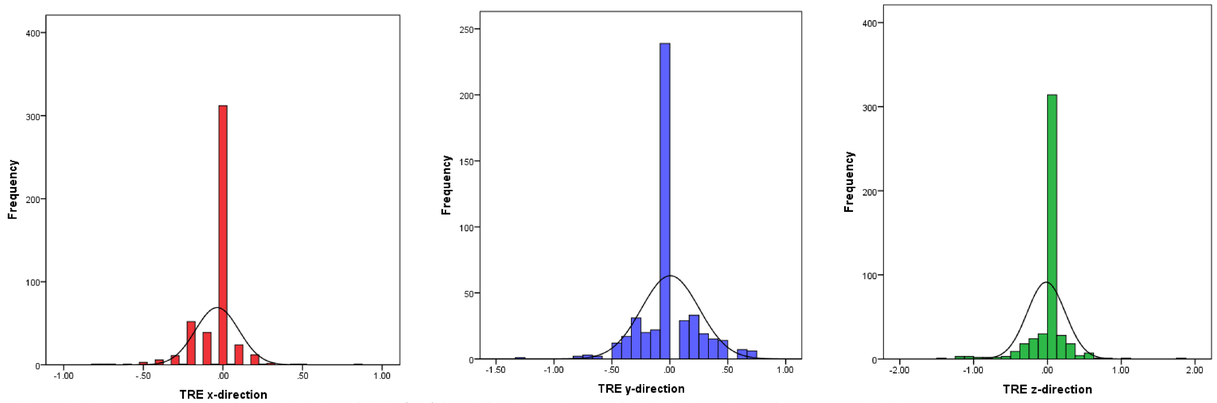

Figure 2 Histograms showing the distribution of TREs (cm) for all fractions. Red = Left-Right, Blue= Sup-Inf, Green= Ant-Post

Conclusions

- While further research is recommended to include more participants, the researchers concluded that the immobilisation technique used is adequate for lung VMAT as well as for the future implementation of SBRT.
- 4DCT planning is recommended for more accurate TRE measurements as well as to adapt margins to the individual patient through internal target volumes (ITVs).
- Retaining daily IGRT and attempting to reduce planning target volumes (PTVs) is recommended to spare normal tissue.

References

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