Audit of head and neck set-up accuracy in radical head and neck radiotherapy

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ABSTRACT

Aims: To evaluate the set-up accuracy of a new thermoplastic immobilization device in 75 head and neck (HN) patients; to evaluate the systematic error introduced by orthogonal simulator reference-images and the impact of weight loss on set-up error in a subgroup of 25 HN chemoradiotherapy patients.
Methods: Data collected from radiotherapy records and VARIS system. Systematic and random errors calculated. Spearman's rho two-tailed correlation analysis used for the sub-group analysis.
Results: For the whole group, ~90% displacements were <3mm. Systematic errors were 0.8mm in all directions and random errors 1.3mm antero-posterior/supero-inferior and 1.4mm right-left. CTV to PTV margin was calculated as 3mm (vanHerk). Subgroup analysis: A systematic error was introduced in 11(44%) patients and the strongest correlation found was between the treatment mean and the mean of the first 3 fractions (r=0.5A-P, r=0.8S-I, r=0.8R-L, p<0.001). A significant difference in mean set up error in the anterior-posterior position when weight lost >7% of pre-treatment weight found.
Conclusions: Levels of set up accuracy compares well to published data and is therefore suitable for HN IMRT. Verification protocols were reviewed and amended.

BACKGROUND

- Ensuring the accuracy of radiotherapy (RT) delivery in head and neck tumours is paramount due to the complexity of the regional anatomy and close proximity of organs at risk to the target volume.
- A new head and neck thermoplastic 5-point fixation immobilisation device was introduced at SLCC in 2007.
- Pre-treatment verification of 3-DRT plans is routinely carried out in simulator and the images generated used as reference images. This can potentially introduce systematic errors.
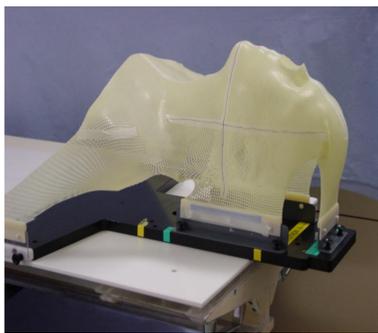
OUTCOME MEASURES

- Proportion of measurements <3mm and <5mm.
- Systematic Set-up Error (SSE) and Random Set-up Error (RSE).
- Subgroup analysis 1: SSE introduced by using simulator orthogonal images as reference images and correlation with SSE throughout treatment.
- Subgroup analysis 2: Impact of weight loss on SSE in patients treated with chemoradiotherapy.

METHODS

- Data was analysed from a prospective database of 75 patients treated with RT between December 2007 and August 2008.
- Simulator orthogonal images were generated and used as reference images using an off-line correction protocol.

OFF-LINE CORRECTION PROTOCOL

	Gross correction action level	Systematic correction action level	Tolerance
Translation (mm)	5	3	3
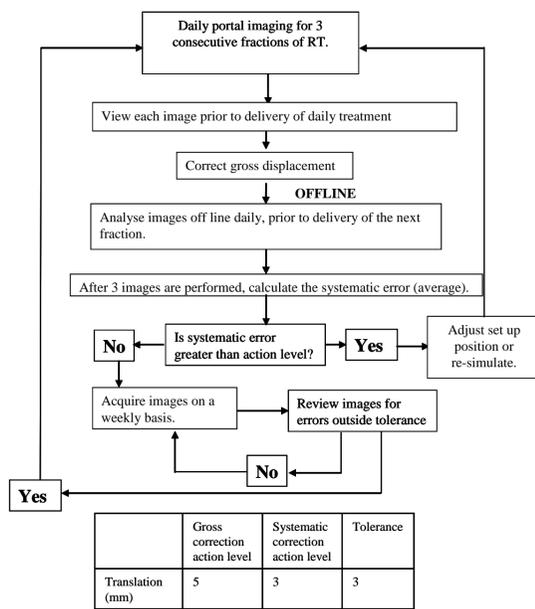
- The value and direction of translational displacements in the simulator images and EPIs were recorded. Statistical analysis was performed using SPSS v.11 for Windows.

RESULTS 1

A total of 3193 measurements were obtained and analyzed, 1592 in the S-I direction, 924 in the R-L direction and 677 in the A-P direction.

CTV to PTV margin set at 3mm in all directions

Table 1. Proportion of measurements <5mm, ≤3mm and <3mm in the S-I, R-L and A-P directions.

	S-I	R-L	A-P
<5mm	98%	97%	08%
≤3mm	96%	95%	95%
< 3mm	90%	89%	90%

Table 2. Summary of SSE and RSE and CTV to PTV margin calculation

(vanHerk 2.5 x systematic set-up errors (?) + 0.7 x random set-up errors (σ'))

		SSE	RSE	2.5*SSE	0.7*RSE	Sum
A-P film	S-I	1.0	1.1	2.5	0.8	3.3
	R-L	0.7	1.2	1.8	0.8	2.6
Lat film	S-I	0.8	1.1	2.0	0.8	2.8
	A-P	0.8	1.3	2.0	0.9	2.9
A-P neck	S-I	1.2	1.4	3.0	1.0	4.0
	R-L	1.1	1.9	2.8	1.3	4.1
Combined S-I		0.8	1.3	2.0	0.9	2.9
Combined R-L		0.8	1.4	2.0	1.0	3.0

RESULTS 2

Introduction of SSE when using simulator image as reference image
- 25 patients having ChemoRT evaluated

Table 3. Isocentre displacements in simulator images with reference to isocentre position on planning CT scan

	A-P image		Lateral image	
	S-I	R-L	S-I	A-P
0	21 (84%)	23 (92%)	22 (88%)	16 (64%)
1mm	2 (8%)	1 (4%)	3 (12%)	7 (28%)
2mm	2 (8%)	1 (4%)		1 (4%)
3mm				1 (4%)

Table 4. Direction of isocentre displacements in simulator images

A-P image		Lateral image	
S	2/4 (50%)	S	1/3 (33%)
I	2/4(50%)	I	2/3 (67%)
R	2/2 (100%)	A	5/9 (55.5%)
L	0	P	4/9 (44.6%)

- A systematic error was introduced in 11 (44%) patients by using the simulator images as reference images, 5 in the A-P images and 10 in the lateral images.
- Simulator images did not show a statistically significant correlation with EPI set-up measurements.

- There was a statistically significant correlation between set up during the 1st treatment fraction and the mean (systematic error) of the first 3 fractions (r=0.7 A-P, r=0.7 S-I and r=0.8 R-L, all p<0.0001) and the mean throughout the treatment course (r=0.5 A-P, r=0.5 S-I, r=0.7 R-L, p=0.02 A-P and p<0.0001 S-I and R-L).

- A strong correlation was found between the treatment mean with the mean of the first 3 fractions (r=0.5 A-P, r=0.8 S-I, r=0.8 R-L, all p<0.001).

Table 5. Summary of significant correlations (Spearman's rho, two-tailed)

	1st treatment fraction	Average of 1st 3 fractions	Average throughout treatment course
1st treatment fraction	N/A	A-P direction on lateral image 0.7 (p<0.0001)	A-P direction on lateral image 0.5 (p=0.02)
		S-I direction on lateral, A-P and neck images 0.7 (p<0.0001)	S-I direction on lateral, A-P and neck images 0.5 (p<0.0001)
		R-L direction on A-P and neck images 0.8 (p<0001)	R-L direction on A-P and neck images 0.7 (p<0.0001)
Average of 1st 3 fractions	N/A	N/A	A-P direction on lateral image 0.5 (p=0.009)
			S-I direction on lateral, A-P and neck images 0.8 (p<0.0001)
			R-L direction on A-P and neck images 0.8 (p<0.0001)

RESULTS 3

Impact of weight loss on set up error in having ChemoRT

Weight loss is associated with changes in shape which can have an impact on patient set up.
25 patients having ChemoRT were evaluated
All had a prophylactic percutaneous gastrostomy tube (PEG) prophylactically inserted.

Table 6. Patient characteristics

Tumour site	Number
Oropharynx	18
Larynx	2
Nasopharynx	2
Oral cavity	3
Median age (range) in years	59 (42-81)
Chemotherapy regimen	
Weekly cisplatin	15
3-4 weekly cisplatin	5
Weekly Carboplatin	2
Cetuximab	3
Pre-Treatment Weight in Kg	75.1 (±12.7)
Post-Treatment Weight in Kg	70.6 (±12.9)
RT fractionation regimes	
45Gy/25F	1
60Gy/30F	1
64Gy/32F	2
65Gy/30F	3
66Gy/33F	9
68.9Gy/34F	1
70Gy/35F	7

Out of a total of 25 patients, 3 (12%) gained weight, 5 (20%) lost less than 5% of their initial body weight, 15 (60%) lost between 5% and 10% and 2 (8%) lost more than 10%.

Table 7. Weight statistics

	Pretreatment weight (Kg)	Week 6-7 weight (Kg)	Weight difference in Kg	% wt loss
Mean (±SD)	75.1±12.7	70.6±13.0	-4.5±3.7	-6%±5%
Median	73.4 (52.3 -112)	69.1 (48.1-110)	-4.7 (-14.2 - 1.5)	-6% (-17% - 2)

Table 8. Weight statistics over time

	Percentage wt loss pre-Tx to week 4	Percentage wt loss week 4 to end Tx	Percentage wt loss pre-Tx to end Tx
Mean (±SD)	-2%±3%	-4%±4%	-6%±5%
Median	-3% (-7% to 5%)	-3% (-13% to 4%)	-6% (-17% to 2)

- Patients lost, on average, double the amount of weight from week 4 of treatment to the end of treatment than in the first 4 weeks.
- A statistically significant correlation was found between the percentage of weight loss up to week 4 (r=0.6, p=0.002) and between weeks 4 and end of treatment (r=0.5, p=0.007) and total weight loss.
- A trend was found for larger mean AP set-up errors as patients lost larger proportion of total body weight, which reached statistical significance in patients who lost >7% (0.7mm, p=0.03, Wilcoxon Signed Ranks Test).

CONCLUSIONS

- Analysis of set-up errors confirms that the thermoplastic immobilisation device introduced at SLCC in 2007 provides a level of set up accuracy that compares well to published data and is therefore suitable to use as routine in the treatment of radical 3D-CRT and IMRT treatments of the HN region.
- A CTV to PTV margin for set-up of 3mm in all directions is appropriate.
  - Simulator images introduce a SSE in up to 36% patients in the A-P direction, 12-16% in S-I direction and 8% in the R-L direction.
  - The mean set-up during the 1st 3 fractions should be considered a more realistic isocentre for the treatment course.
  - Weight loss is a significant problem that is likely to have a negative impact in set-up errors, particularly in patients who lose >7% of their body weight.

ACTIONS
- CTV to PTV margin confirmed at 3mm.
- DRRs to be used as reference images where appropriate.
- Protocol for intensive feeding approach to be designed.
- Re-audit planned in 1year.

REFERENCES

- On Target: Ensuring Geometric Accuracy in Radiotherapy, RCR, 2008
- Van Herk et al. The probability of correct target dosage: dose- population histograms for deriving treatment margins in radiotherapy. IJROBP, 2000

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