Comparison of three immobilisation systems for radiation therapy in Head and Neck Cancer

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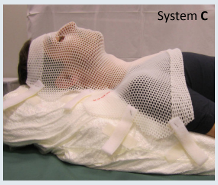
INTRODUCTION

Daily online Cone Beam CT (CBCT) scans are becoming increasingly common. However, immobilisation remains important since rotational setup errors are generally insufficiently corrected. Rotational errors might especially be of concern in the head and neck region due to the close adjacency of target and organs at risk.

This study investigates the precision of three commercially available immobilisation systems by measuring the random and systematic setup errors for three equal groups of Head and Neck Cancer patients.

METHOD AND MATERIAL

The evaluated systems were: **A)** Orfit AIO base plate, standard neck supports and a pre-cut 5-point reinforced Efficast mask fixed to the base plate with L-shaped profiles, **B)** Q-Fix AccuFix Cantilever Board Featherline base plate with adjustable shoulder locks, Vacfix neck support and a U-Frame Aquaplast mask for the head, and **C)** Aquaplast mask, covering the head and shoulders, fixed to a Vacfix cushion at 8 points with velcro strips (current clinical system in Odense).



Forty-two patients, divided in three equal groups, all receiving 66-68 Gy in 33 fractions were used to evaluate the precision of the three systems. Daily CBCT was performed with a few exceptions yielding a total of 1303 CBCT scans. Automatic registration was performed on the bony structures of the neck (clipbox). Translational and rotational setup errors were extracted from the CBCT system.

The CBCT scans for each immobilisation system was divided into groups of 5 fractions (1-5; 6-10; 11-15; 16-20; 21-25; 26-30 and 31-33). The random and systematic translational and rotational setup errors in lateral, longitudinal and vertical directions were calculated for each group, as described by van Herk (Semin Radiat Onco 1 2004).

For a rotational setup error of more than 3 degrees, the patient was repositioned and a new CBCT scan was acquired (re-scan) before treatment. If a re-scan was performed the prior scan was not included in the analysis. Re-scan frequency was also evaluated.

RESULTS

Translations

The random setup error ($\sigma_{translation}$) for system **A** is less than that for system **B** in all directions ($p < 0.02$) (fig. 1a-c).

System **A** had less $\sigma_{translation}$ than **C** in the lateral direction ($p < 0.002$).

In the longitudinal and vertical directions, difference between $\sigma_{translation}$ for systems **A** and **C** were not statistically significant.

For all systems no large time trends were observed in $\sigma_{translation}$ during the treatment course.

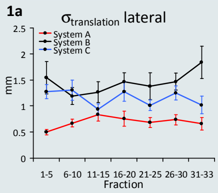
Systematic setup error ($\Sigma_{translation}$) was similar for all systems in the lateral direction.

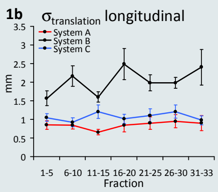
In the longitudinal and vertical directions $\Sigma_{translation}$ for system **A** was less than that for **B** and **C** (table 1).

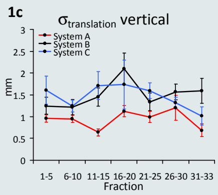
Translational setup errors in **mm**

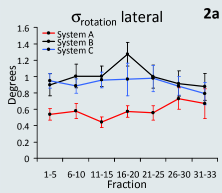
	$\sigma_{translation}$			$\Sigma_{translation}$		
System	Lat	Long	Vert	Lat	Long	Vert
A	0.9	1.0	1.3	1.2	1.0	1.9
B	1.7	2.4	2.1	1.1	2.4	2.6
C	1.4	1.2	1.8	1.3	1.9	2.5

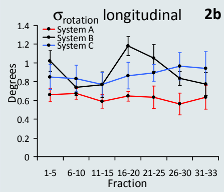
Table 1. Average setup $\sigma_{translation}$ and $\Sigma_{translation}$ for the entire treatment course.

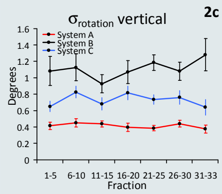












Rotations

Random setup error in rotation ($\sigma_{rotation}$) for **A** was less than that for **B** and **C** in all directions ($p < 0.02$) (Fig. 2a-c).

System **C** had less $\sigma_{rotation}$ than **B** in the vertical direction ($p < 10^{-5}$). There was no statistical difference between **B** and **C** in the lateral and longitudinal directions.

For all systems no large time trends were in $\sigma_{rotation}$ observed during the treatment course.

Systematic setup error ($\Sigma_{rotation}$) for system **A** was less than that for **B** in all directions (see table 2).

In the vertical direction $\Sigma_{rotation}$ for system **A** was less than that for **C**.

The re-scan frequency for **A** was 6.7 %, **B** 11.6 % and **C** 12.5 %.

Rotational setup errors in **degrees**

	$\sigma_{rotation}$			$\Sigma_{rotation}$		
System	Lat	Long	Vert	Lat	Long	Vert
A	0.7	0.8	0.5	0.6	1.0	0.5
B	1.2	1.1	1.3	1.0	1.3	1.1
C	1.1	1.0	0.8	1.3	1.0	0.6

Table 2. Average setup $\sigma_{rotation}$ and $\Sigma_{rotation}$ for the entire treatment course.

DISCUSSION

As daily online CBCT of head and neck cancer patients has become more common, a large part of the translational setup error is corrected. However, rotational setup error is often not sufficiently corrected, since most treatment couches do not correct for rotations. Most margin protocols assume perfect correction of the entire PTV. In case of a rotation, this is only true in a single point. The further away from this point a given structure is, the larger the impact a rotation will have on the precision of the treatment.

Though precise patient setup can be achieved by daily CBCT, repositioning and re-scanning a patient takes effort and time in the day to day treatment of patients. Therefore, the lower re-scan frequency for system **A**, resulting from its low rotational setup error, is desirable.

For other image protocols than daily CBCT, a reduction in setup margin is possible for system **A** compared to **B** and **C**, as demonstrated in table 3, in the extreme (and clinically unlikely) case of no image protocol.

Setup margin in mm

System	Lat.	Long.	Vert.
A	3.6	3.1	5.6
B	3.9	7.6	7.8
C	4.3	5.6	7.4

Table 3. Setup margins given by $2.5\Sigma_{translation} + 0.7\sigma_{translation}$

CONCLUSION

In the current clinical setting, system **A** had statistically significant less setup error than **B** and **C**, overall. Systematic and random setup errors for **A** were as good as, or better than those for **B** and **C**, for both translations and rotations.

In clinical practice, translational setup errors are usually corrected through the use of an image protocol and subsequent shift of the treatment couch. Correction of rotational setup errors requires repositioning and re-scan of the patient. System **A** had lower re-scan frequency than **B** and **C** due to less rotational setup error, reducing the need for time consuming patient repositioning considerably.

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