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Original Article

Reproducibility of the Patient Setup for Head and Neck Cancers using On-Board Imager System

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Abstract

Objective: To study the setup error of patient positioning in head and neck cancer with customized thermoplastic long mask using On-Board Imager (OBI) system.

Materials and Methods: This study is a retrospective analysis of the setup error data from June 2008 to February 2009. The data were collected from 12 head and neck cancer patients with IMRT technique using the thermoplastic long mask for 6 MV photon beams. Two images in AP (anterior-posterior) and lateral views were taken with the On-Board Imager mounted on the gantry of the linear accelerator machine before treating the patient. Then these images were matched with the DRR (Digital Radiographic Reconstruction) images of planning CT by using the OBI software to determine the setup errors in vertical (anterior-posterior), longitudinal (superior-inferior), and lateral (left-right) directions.

Results: From 187 sessions of the matching, the mean values of setup error were 0.19 ± 0.18 cm, 0.21 ± 0.18 cm, and 0.11 ± 0.11 cm for vertical (Vrt), longitudinal (Lng), and lateral (Lat) directions respectively. The maximum setup errors were 0.9 cm, 0.6 cm, and 0.5 cm for Vrt, Lng, and Lat directions from two patients with cutting thermoplastic long mask at the port and neck regions. For normal masks, the maximum values were 0.5 cm, 0.5 cm, and -0.5 cm for Vrt, Lng, and Lat directions.

Conclusion: All setup errors in head and neck cancer of this study are acceptable for thermoplastic long mask without cutting. The OBI system is shown to be useful for reducing the uncertainty of interfraction and increasing the efficiency of radiation therapy.

Key words: Evaluation, Setup error, On-Board Imager, head and neck cancer.

Introduction

In the process of radiation therapy, patient's positioning and immobilization are important because the error may result in the rate of tumor control and patient complication. The optimized radiotherapy is to deliver maximum dose to the tumor and minimum dose to the critical normal tissue. Especially in head and neck cancer, the accuracy of radiation dose to target volume is required due to the proximity of many critical structures such as brain stem, spinal cord, and parotid glands. So reproducibility of the patient positioning is particularly important for increasing the efficiency of radiation treatment.

There are many verification devices that can be used to check the patient's position before treatment such as port film[1], EPID (Electronic portal imaging)[2,3], and kV or MV On-Board Imager (OBI)[4,5]. The kV on-board imager was used in this study. It is qualified to take high quality image, reduce radiation dose to patient, have automated matching software which can automatically shift the couch to the correct position.

Fox et al[6] studied the performance of image registration software and repositioning a 3D offset using OBI software. Verification tests were performed to assess the precision and accuracy of the automated positioning system in a known offset phantom. They found that the average deviation between detected and known offset was less than 0.75 mm. Their conclusion is the precision and accuracy of OBI system checkup daily, setup error margin can be reduced to less than 1.4 mm.

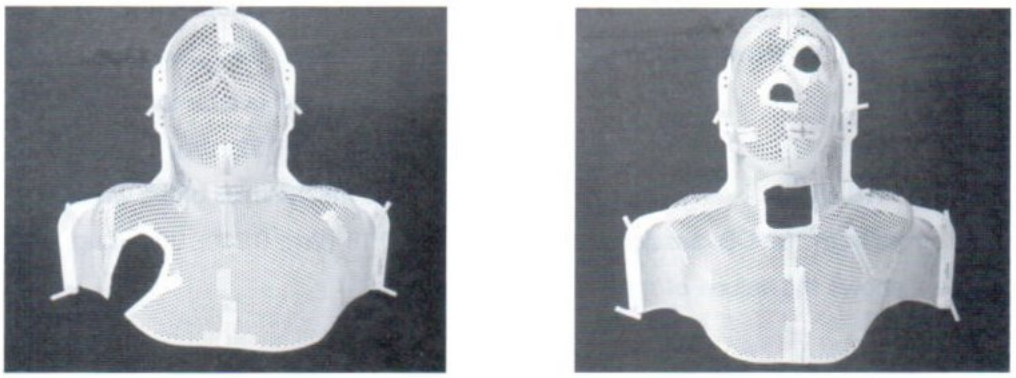
Mechalakos et al[7] performed the measurement of interfraction and intrafraction setup deviations for head and neck cancer patients using a kV OBI. They summarized that the systematic errors were seen in the interfractional data, but not in the intrafractional data, indicating that the mask is better at maintain head position than reproducing it.

Pahlivan et al[8] assessed interfractional setup errors from daily electronic portal images in twenty head and neck cancer patients with a fixed 5 point mask immobilization system. The systematic setup errors were less than 1 mm in the three directions whereas the random setup errors were around 2 mm.

This study was designed to evaluate the setup error of the patient positioning in head and neck cancer with customized thermoplastic long mask using kV On-Board Imager system.

Materials and Methods

This study is a retrospective analysis of the setup error data in 12 head and neck cancer patients treated with IMRT (Intensity modulated radiation therapy) technique, by using 6 MV photon beams from a Varian linear accelerator (Trilogy®, Varian Medical System, Palo, Alto) at Radiation Oncology Division, Chulabhorn Cancer Centre. The data was collected from June, 2008 to February, 2009. All patients were immobilized with a thermoplastic long mask (TYPE-S™) covering head, neck, and shoulder but two of them were cut for patient comfortable as shown in Fig.1. (a) and (b) respectively. The mask was fixed to the couch of the treatment machine. At the treatment couch, the patients were setup by using lasers aligned to skin markers on the mask. Orthogonal verification images (anterior-posterior and lateral) were taken with the kV On-Board Imaging device permanently mounted on the gantry of the linear accelerator machine. Then both images were matched with the DRRs (Digitally Reconstructed Radiographs) from planning CT by using the OBI software.



(a) (b)

Fig.1 The thermoplastic long masks with cutting parts. (a) at the port area and (b) at the neck, nose and eye area.

Image analysis

The OBI and reference images were overlaid in gray scale and aligned by using auto-matching software then manual matching of bony anatomy drawn on the reference images. For the first fraction, the alignment was evaluated by the oncologist. Fig.2 shows the OBI console of matching result with Split Window.

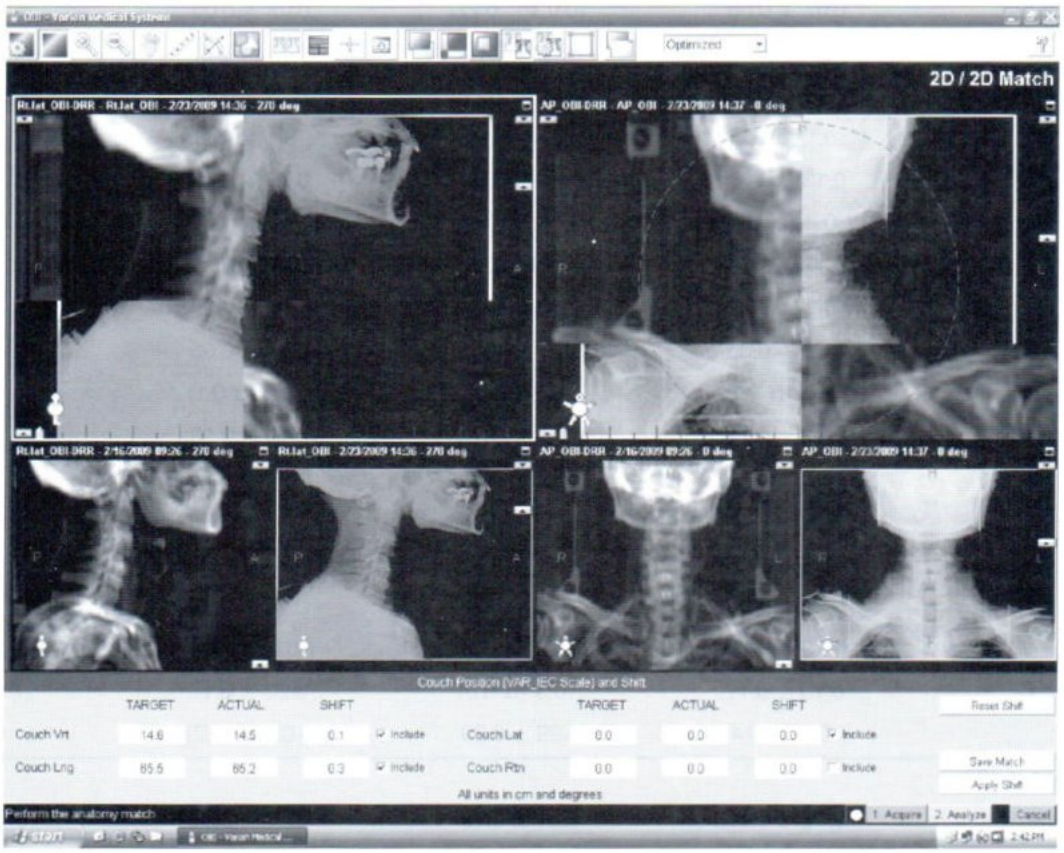


Fig.2 OBI console showing overlaid images and couch shift (error) values.

The shifted or error values of the couch for all directions (Vrt, Lng and Lat) shown on the console were recorded.

Results

The setup errors from 187 OBI sessions were evaluated. Table 1 shows the values of mean ± SD of interfractional setup errors. The patients no. 1 and no. 2 having the cutting masks at the port and neck, nose and eye area present the maximum errors of 0.48 ± 0.22 (Vrt), 0.42 ± 0.08 (Lng) respectively. The mean errors of the whole population were 0.19 ± 0.18 (Vrt), 0.21 ± 0.18 (Lng) and 0.11 ± 0.11 (Lat).

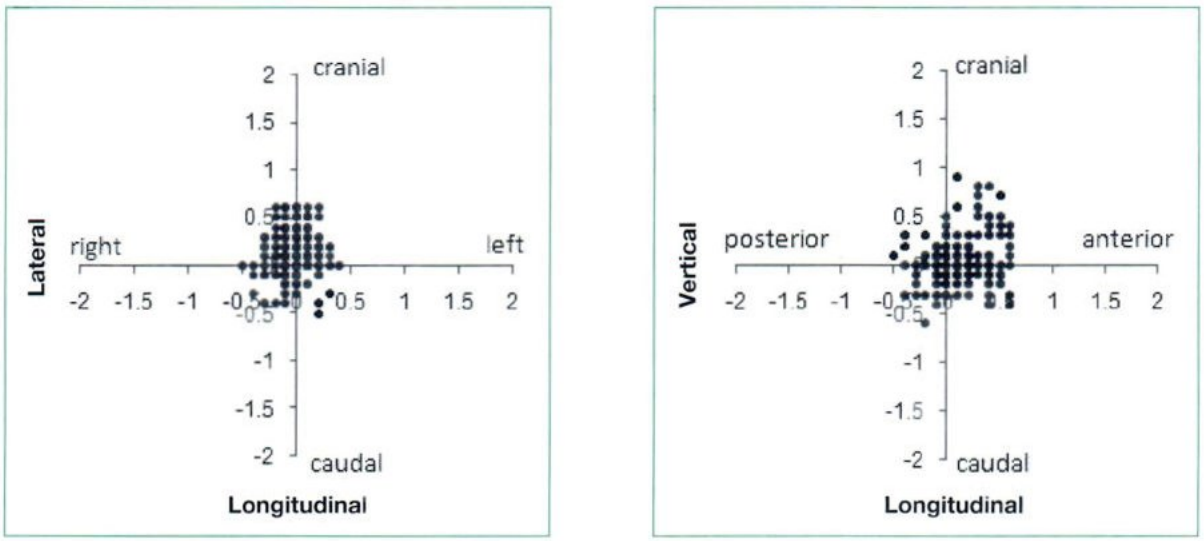
Table 1 The values of mean ± SD, minimum and maximum of interfractional setup errors

Patient No.	Mean ± SD of individual patient setup error			No. of OBI
	Vrt.	Lng.	Lat.	
1	0.48 ± 0.22	(0.0 to 0.9)	0.40 ± 0.16	27
	(0.0 to 0.6)	0.10 ± 0.10	(-0.3 to /0.0)	
2	0.10 ± 0.10	(-0.4 to 0.1)	0.42 ± 0.08	29
	(0.3 to 0.6)	0.05 ± 0.06	(-0.1 to 0.1)	
3	0.14 ± 0.11	(-0.3 to 0.3)	0.04 ± 0.06	15
	(0.1 to 0.2)	0.13 ± 0.10	(-0.2 to 0.3)	
4	0.07 ± 0.08	(0.0 to 0.2)	0.07 ± 0.05	6
	(-0.1 to 0.1)	0.12 ± 0.10	(0.0 to 0.3)	
5	0.13 ± 0.05	(0.1 to 0.2)	0.18 ± 0.10	4
	(0.1 to 0.3)	0.03 ± 0.05	(-0.1 to 0.0)	
6	0.13 ± 0.08	(-0.1 to 0.3)	0.08 ± 0.08	6
	(-0.2 to /0.0)	0.08 ± 0.10	(-0.2 to 0.0)	
7	0.12 ± 0.11	(0.0 to 0.3)	0.22 ± 0.11	5
	(0.1 to 0.4)	0.10 ± 0.07	(-0.2 to /0.0)	
8	0.04 ± 0.05	(-0.1 to 0.0)	0.04 ± 0.05	5
	(-0.1 to 0.1)	0.08 ± 0.08	(-0.2 to 0.1)	
9	0.16 ± 0.12	(-0.4 to 0.3)	0.10 ± 0.10	21
	(-0.3 to 0.3)	0.12 ± 0.10	(-0.4 to 0.0)	
10	0.14 ± 0.13	(-0.3 to 0.2)	0.11 ± 0.08	27
	(-0.3 to 0.2)	0.16 ± 0.15	(-0.3 to 0.3)	
11	0.22 ± 0.14	(-0.4 to 0.5)	0.19 ± 0.15	22
	(-0.3 to 0.5)	0.15 ± 0.11	(-0.2 to /0.4)	
12	0.15 ± 0.11	(-0.3 to 0.3)	0.20 ± 0.17	20
	(-0.5 to 0.4)	0.09 ± 0.09	(-0.3 to 0.2)	
Mean ± SD for the whole population	0.19 ± 0.18	0.21 ± 0.18	0.11 ± 0.11	187

If only the patients with complete masks were taken into account, the mean errors of the three directions would be decreased to 0.13 ± 0.05 (Vrt), 0.12 ± 0.07 (Lng) and 0.11± 0.04 (Lat).

From the scatter plots of the setup errors in AP and lateral views (Fig. 3 a and b), it would seem to appear that the errors were more in Lng+ (cranial) and Vrt+ (anterior) directions.

Table 2 illustrates the number of OBI sessions for each range of errors and also in the percentage of all sessions for head and neck cancer patients. The results show the errors within 0.5 cm with 93%.



(a) (b)

Fig. 3 Scatter plots of the setup errors for all head and neck patients in anterior-posterior image (a) and lateral image (b).

Table 2 Setup errors of the couch position along the three directions (Vrt, Lng and Lat) for head and neck cancer patients.

Range of setup error (cm)	Frequency		
	Vrt	Lng	Lat
0 - 0.1	105 (56%)	89 (47%)	134 (72%)
0.2 - 0.3	56 (30%)	50 (27%)	48 (25%)
0.4 - 0.5	14 (7%)	39 (21%)	5 (3%)
0.6 - 0.7	9 (5%)	9 (5%)	0 (0%)
0.8 - 0.9	3 (2%)	0 (0%)	0 (0%)
Total	187 (100%)	187 (100%)	187 (100%)

95%, and 100% for anterior-posterior (Vrt), superior-inferior (Lng), and left-right (Lat) directions respectively. The maximum errors were 0.9 cm, 0.6 cm, and 0.5 cm for Vrt, Lng and Lat directions in two patients with cutting thermoplastic long masks.

Discussion

With the OBI unit attached to the treatment machine, the patient images taken before treatment are used to estimate the setup errors by comparing with the standard images from the treatment planning. From the setup errors in the three directions, Vrt, Lng, and Lat evaluated by the OBI software, the couch positions can be automatically shifted to the right values.

According to this study, the setup errors were within 0.5 cm with the maximum mean value of 0.22 cm in all couch directions with the complete masks (no cutting area) which are acceptable for the conventional treatment. Our results are preferable than the study of Fox et al (6) (average deviation = 0.75 mm) and comparable with the study of Mechalakos et al (7) that report the mean values of -0.1 ± 0.3 cm, -0.2 ± 0.3 cm, and 0.0 ± 0.2 cm and Pehlivan et al[8] that propose the mean value of 0.2 cm. The setup error values with 0.9 cm and 0.6 cm for Vrt. and Lng. directions respectively were recorded for 2 patients with the cutting masks, one at the port region and another one at the neck, nose and eye. The error increased and direction of increase depend on the location and size of the cutting region.

Conclusion

From our study, it can be concluded that the long thermoplastic mask is very useful in reproducibility of patient setup or reducing the uncertainty of interfraction for head and neck cancer patient. If the mask has to be cut, the setup error may be up to 1 cm, so the larger PTV has to be considered. The OBI system is shown to be very beneficial that the patient will be treated with very close position to the planning which will increase the tumor control probability and decrease complication rate of the patient especially when the tumor is very close to critical organs and a cutting mask is used.

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