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An Automatic Registration Comparison Between Partial Cone Beam CT and Full Cone Beam CT for Breast Cancer

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ABSTRACT

To evaluate an automatic registration of partial cone beam CT scan's and full cone beam CT scan's position errors, durations and doses for breast cancer. Before the treatment's of breast cancer patients using Versa HD, five breast cancer patients were scanned in the same position with partial cone beam CT and a full cone beam CT in sequence. The full cone beam CT parameters corresponded to the default VolumeView "Chest M20" preset in XVI 4.5, partial cone beam CT parameters were set by us. Both cone beam CT scans were performed in 3 dimensions with for rotational bone value registration, gray value registration and rotational gray value registration. Firstly, we found an average difference of 1.46mm in lateral direction,1.86mm in longitudinal direction and 1.92mm in vertical direction difference for bone value rotational automatic registration. Secondly, we determined an average 1.24mm in lateral direction,1.36mm in longitudinal direction,1.58mm in vertical direction difference for gray value rotational automatic registration. Thirdly, we determined an average 1.52mm in lateral direction,1.88mm in longitudinal direction,1.52mm in vertical direction difference for gray value automatic registration. When we measured radiation at the isocentre point for both cone beam CT tecniques, point dose decreased %55±5 with partial cone beam CT scan. Additionally, cone beam CT scan's duration decreased %40 with partial cone beam CT scan.

Keywords: Breast Cancer, CBCT, Versa HD, XVI

1 INTRODUCTION

Intensity-modulated radiotherapy (IMRT) techniques make it possible to create a complex conformal treatment plan. This is achieved by breaking each treatment beam into smaller beam segments [1]. This modality has been shown to improve dose homogeneity and reduce doses to OARs compared with three-dimensional conformal radiotherapy (3D-CRT). Improved dose homogeneity through the use of IMRT can reduce the occurrence of moist desquamation and other toxicities, thus improving quality of life for patients [2]. The integration of kilo voltage cone beam computed tomography (kv -CBCT) imaging systems into linear accelerators makes it possible to image and treat a patient on a single machine. CBCT in image-guided radiotherapy (IGRT) offers a tremendous advantage for treatment guidance. A kV-CBCT image set consists of a number of two-dimensional (2D) projection images acquired at different positions around the patient and reconstructed into a 3D volume. A kV-CBCT provides bony anatomy as well as soft tissue information that allows the visualization of the tumor and surrounding organs at risk before treatment [3]. CBCT images acquired during the radiotherapy course shows anatomical changes in a significant fraction of the patients. Such a change can have considerable influence on the dose distribution both for the tumor and for the normal tissue. This calls for adaptive radiotherapy where radiation fields are adjusted according to the new geometry. CBCT images are routinely used for positioning of the patients. The positioning is based on a major data reduction which only extracts the translation and rotation needed to correct the patient position. However, it is possible to obtain much more information from daily use of CBCT images.

A daily kV-CBCT for patient position verification before these advanced treatment techniques may increase the patients normal tissue dose owing to the multiple treatment fractions requiring imaging. This is of particular concern for organs at risk surrounding the tumor volume, which would receive only a small dose from the treatment alone.

The goal of this study is to evaluate an automatic registration of partial cone beam CT scan's and full cone beam CT scan's position errors, durations and doses for Breast Cancer.

2 MATERIALS AND METHOD

As shown in Figure 1; Versa HD (Elekta; Stockholm, Sweden) machine was installed in Yeni Yuzyil University Gaziosmanpasa Hospital. It is equipped with as shown in Figure 2; XVI 4.5 accessory with cone-beam CT (CBCT) (Elekta; Stockholm, Sweden) image capabilities. Five patients undergoing definitive 6 fields dynamic IMRT for breast cancer were included in this study. Before the IMRT treatment's of breast cancer patients using Versa HD, five breast cancer patients were scanned in the same position with partial cone beam CT and a full cone beam CT in sequence. The patient position errors were determined using automatic registration methods in both cases.

The full cone beam CT parameters corresponded to the default Volume View "Chest M20" preset in XVI 4.5; 360 degree, 180 deg/min velocity, 120 kV, 660 frames, 1056 mAs and nominal scan dose of 22 mGy. Partial cone beam CT parameters were set by us, we choosed S20 filter instead of M20 filter and for right breast; gantry angle was CW direction from 180° to 10°, for left breast; gantry angle was CW direction from 300° to 130°, 180 deg/min velocity, 100 kV, 366 frames, 585.6 mAs. Both cone beam CT scans were performed in sequence for five patients and position errors in 3 dimensions recorded using automatic registration method with for rotational bone value registration, gray value registration and rotational gray value registration.

Figure 1: Elekta Versa HD

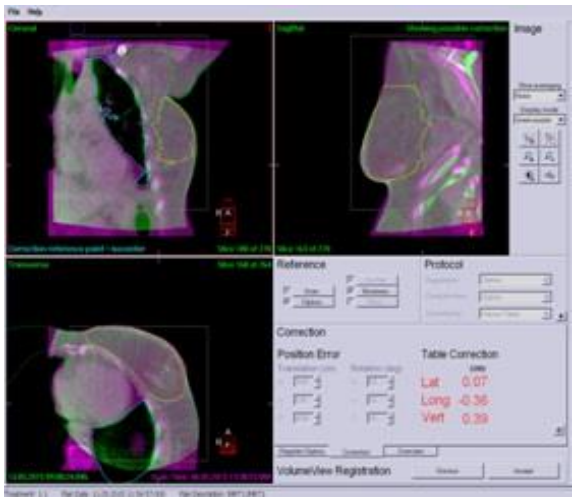

Figure 2: XVI 4.5 CBCT Scan

3 RESULTS

Table 1 lists the automatic registration of partial cone beam CT scan's position errors and full cone beam CT scan's position errors. Firstly, we found an average difference of 1.46 mm in lateral direction, 1.86 mm in longitudinal direction and 1.92 mm in vertical direction difference for bone value rotational automatic registration. Secondly, we determined an average 1.24 mm in lateral direction, 1.36 mm in longitudinal direction, 1.58 mm in vertical direction difference for gray value rotational automatic registration. Thirdly, we determined an average 1.52 mm in lateral direction, 1.88 mm in longitudinal direction, 1.52 mm in vertical direction difference for gray value automatic registration.

When we measured radiation at the isocentre point using cylindrical ion chamber with 30 cm x 30 cm solid phantom for both cone beam CT tecniques, radiation dose decreased % 55±5 with partial cone beam CT scan. Previous studies have measured the dose to limited locations from a kV-CBCT acquired for breast radiotherapy setup; 2 to 7 cGy to the skin [4], [5], 2 to 4 cGy to the contra-lateral breast [5], and 2 to 5 cGy to the lungs [5]. As survival rates increase, long-term effects, such as radiation-induced second cancers, become a concern, and this additional dose may become an issue.

Optimal image acquisition parameters for breast radiotherapy setup will depend upon the purpose of the CBCT scan. Additional images acquired during a patient's radiotherapy treatment may be used for verifying patient setup and tumor location, assessment of treatment for re-planning, and as an additional quality assurance measure to assess the daily dose delivery. The required image quality for the scan, as determined by the purposes mentioned, will determine the minimum delivered dose achievable.

Table 1. An automatic registration of Partial CBCT and Full CBCT

Patient	Type of CBCT	Direction	Bone (T+R) (cm)	Gray Value (T+R) (cm)	Gray Value (T) (cm)
1	Partial CBCT	X	0.37	0.31	0.64
		Y	0.09	0.29	0.10
		Z	0.00	0.34	0.39
	Full CBCT	X	0.46	0.12	0.50
		Y	0.28	0.07	0.04
		Z	0.02	0.04	0.12
2	Partial CBCT	X	0.99	1.02	1.33
		Y	1.42	1.72	1.34
		Z	0.87	-1.43	-1.01
	Full CBCT	X	1.31	1.08	1.55
		Y	1.14	1.81	1.76
		Z	0.53	-1.44	-1.08
3	Partial CBCT	X	0.47	-0.76	-0.60
		Y	0.84	0.67	0.77
		Z	-0.15	-0.40	-0.33
	Full CBCT	X	-0.48	-0.70	-0.60
		Y	0.56	0.74	0.81
		Z	0.01	-0.33	-0.23
4	Partial CBCT	X	0.11	0.02	0.22
		Y	0.29	0.44	0.39
		Z	-0.27	-0.44	-0.03
	Full CBCT	X	0.07	-0.28	-0.09
		Y	0.32	0.63	0.68
		Z	-0.02	-0.50	-0.25
5	Partial CBCT	X	0.31	0.32	0.24
		Y	-0.33	-0.28	-0.43
		Z	-0.99	-0.90	-0.96
	Full CBCT	X	0.04	0.33	0.15
		Y	-0.48	-0.39	-0.56
		Z	-0.80	-1.17	-1.06

4 CONCLUSION

The results based on cone beam CT images agree with those based on conventional CT images for breast cancer IMRT treatment plans. For the kV-CBCT (100 kV, 366 frames, 585.6 mAs and 180° arc) acquired in a breast radiotherapy treatment position (isocentre located within the treated breast). In spite of the partial cone beam CT scan's image quality were worse than full cone beam CT scan, the automatic registration parameter's difference were below 2.0 mm in 3 dimensions. Most probably these differences are resulting from time difference between two cone beam CT scans and also it could be related with patient's breathing phase during scanning. When we measured radiation at the isocentre point for both cone beam CT tecniques, point dose decreased %55±5 with partial cone beam CT scan. Additionally, Cone beam CT scan's duration decreased %40 with partial cone beam CT scan. The study demonstrates that partial CBCT described here is feasible for breast cancer's treatment.

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