

Clinical Utility of Six Degrees of Freedom Patient Alignment in Non-cranial Lesions

C.F. Njeh, H. Salmon, and V. Goutsouliak
Franciscan Health, Indianapolis, IN, USA

INTRODUCTION

The fundamental tenet of radiotherapy is the delivery of high radiation dose to the tumor while minimizing the dose to surrounding normal tissues. Recent developments in conformal radiation therapy have made reduction in treatment margin, dose escalation, and radiation toxicity reduction a reality. However, there are still geometric errors that need to be addressed to improve dose delivery accuracy. The introduction of image guided radiation therapy (IGRT) has the potential of improving dose delivery accuracy by minimizing setup errors. Most linac with IGRT employs four degrees of freedom couch, which is only able to correct the patient setup in the X-Y-Z planes, as well as the couch rotation angle.

AIM

Tumor translational and rotational uncertainties have been identifies as a significant cause of dose delivery inaccuracy in radiation therapy. Recent six degrees of freedom (6DOF) treatment couches have the ability to align the patient for rotational and translational (roll, pitch and yaw)) movements. The objective is to determine the clinical utility of rotational corrections by quantifying rotational movements for non-cranial lesions

METHOD

Kilo-Voltage cone beam CTs (CBCT) were acquired before radiation therapy of 1522 fractions for a total of 51 patients. These included 15 prostate, 11 pelvic, 15 lung and 10 head and neck disease sites. Each site was treated using a site specific immobilization device. During the setup, patient anatomy from planning CT was automatically registered to the KV-CBCT using both the mask and clip-box protocol. The translational and rotational shifts were generated by the image registration and executed by the 6DOF robotic couch (Elekta iGuide). Both the systematic and random rotational errors were calculated as defined by Van Herk. The magnitude of the translational shifts was calculated as the quadratic square roots of the sum of the 3 axis.

RESULTS

The maximum correctable rotational errors using the 6DOF couch is 3 degrees.

The rotational error distribution were not a standard normal distribution around the mean.

There were significant spread in the rotational errors that were site and patient dependent (see Figure 1).

The systematic errors are given in Table 1.

For the prostate the random errors were: 0.58(roll), 1.25(pitch) and 0.53(yaw).

For Pelvis, the random errors were: 0.42(roll), 1.22(pitch) and 1.05(yaw).

Similar magnitude of errors were observed for the lung and Head and neck.

There were more than 60% of pelvis and 25% of prostate alignments with more than 1 degree of roll rotational correction.

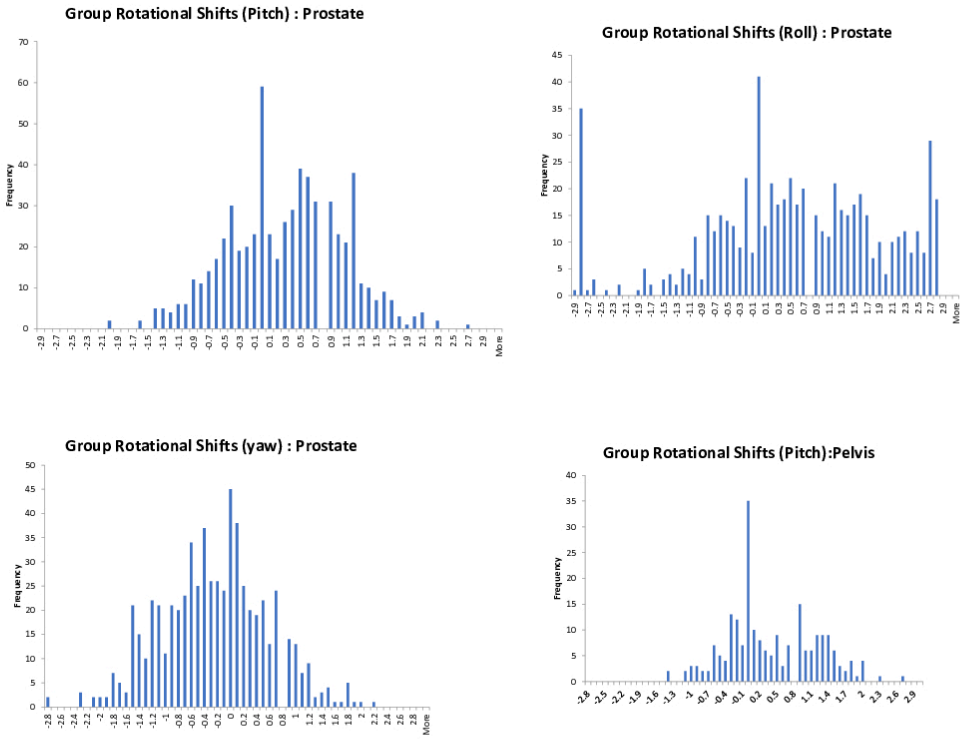


Figure 1: The spread of rotational corrections for patients with prostate cancer and Pitch for Pelvis patients

	Translational			Rotational		
	Mean shifts (mm)	STDev (mm)	Change over time (mm)	Roll	Pitch	Yaw
H&N	4.3	2.0	1.6	0.88	1.08	1.18
Lung	7.9	3.2	-1.5	1.02	0.91	0.91
Pelvis	7.4	3.7	None	0.77	1.31	1.02
Prostate	7.5	3.0	2.2	0.65	1.40	0.84

Table 1 : The absolute mean translational shifts (square root of the sums of the three axis) and absolute rotational shifts

		Translational (mm)					Rotational (Degree)		
	N	SupInf	LR	AP		Roll (x)	Pitch(y)	Yaw(z)	
H&N	7	-0.92	0.82	-1.23		0.42	0.68	-0.59	
Lung	15	0.40	0.93	-1.38		-0.61	-0.13	-0.66	
Pelvis	11	-1.25	-0.35	-0.68		0.31	-0.25	-0.01	
Prostate	14	-1.42	-1.56	0.30		0.33	0.44	-0.25	

Table 2: The systematic errors for the translational shifts and rotational shifts- the closeness to zero means no systematic error

CONCLUSIONS:

Site and patient dependent significant rotational corrections were observed for all anatomical sites.

There was a change in the magnitude of translational shifts over the period of treatment for all sites except for pelvis.

Significant pitch rotation was observed in the prostate and pelvis, roll rotation for lung and yaw rotation for head and neck patients.

With the availability of 6DOF couch, rotational setup errors should be corrected for all SBRT.

For non-SBRT treatments, the need for daily 6DOF alignment should be reviewed for the first five fractions.

Used IGRT and 6DOF for fine tune alignment , not for gross alignment

ACKNOWLEDGEMENTS

We would like to thank our Mooresville radiation therapists Theresa Simpson and Kyla Dobson who acquired all the data.

REFERENCES

Schmidhalter, D., M. K. Fix, M. Wyss, N. Schaer, P. Munro, S. Scheib, P. Kunz and P. Manser (2013). "Evaluation of a new six degrees of freedom couch for radiation therapy." *Med Phys* **40**(11): 111710

Mancosu, P., G. Reggiori, A. Gaudino, F. Lobefalo, L. Paganini, V. Palumbo, A. Stravato, S. Tomatis and M. Scorsetti (2015). "Are pitch and roll compensations required in all pathologies? A data analysis of 2945 fractions." *Br J Radiol* **88**(1055): 20150468.

Njeh, CF, Synder KC and Cai J (2019). The use of six degrees of freedom couch i solely clinically beneficial in stereotactic radio surgery . *Medical Phys* **46**(2) : 416-418

CONTACT INFORMATION

Christopher.njeh@natmedphysics.com.