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Evaluation of transbronchial implanted fiducials for lung tumor tracking in Cyberknife

養和醫院
Hong Kong Sanatorium & Hospital

Y.Y. Chan & K. M. Ku
Department of Radiotherapy, Hong Kong Sanatorium & Hospital, Hong Kong

Objectives

Stereotactic body radiotherapy (SBRT) for lung tumor is a high-dose precision technique requiring accurate target tracking. Fiducials as surrogates of tumor position can be used for tracking in Cyberknife (Accuray, Inc.) but fiducial migration may affect the feasibility of the treatment.

There are two common approaches to implant fiducials for lung cancer patients: transthoracic and transbronchial. The transthoracic approach is associated with higher risk of pneumothorax. In our hospital, fiducials were implanted transbronchial under fluoroscopic guidance.

The purpose of this study was to evaluate the use of transbronchial implanted fiducials for tracking in lung cancer patients who were planned to have SBRT in Cyberknife in terms of safety, stability and traceabilty.

Materials/Methods

This retrospective study included 13 lung cancer patients. Fiducials measured 0.8 x 5mm (PointCoil MTCTXPC08) were implanted transbronchial by specialist in respiratory medicine (Fig.1).

CT at exhalation was done the next day after implantation of fiducials (Fig.2). This set of CT was used as reference location of the fiducials. Another set of CT at exhalation was done for radiotherapy planning purpose and to ensure the stability of fiducials on the 5th to 7th days after implantation. The CT scans of post-implantation day and planning day were used to compare the locations of fiducials to assess their relative migration and displacement.

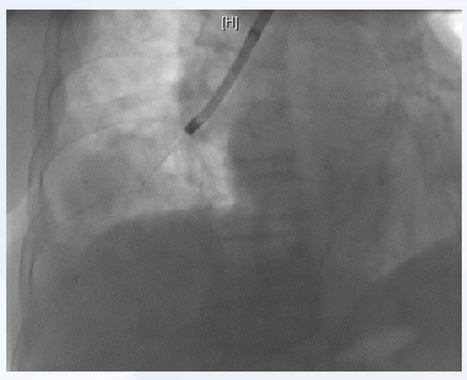


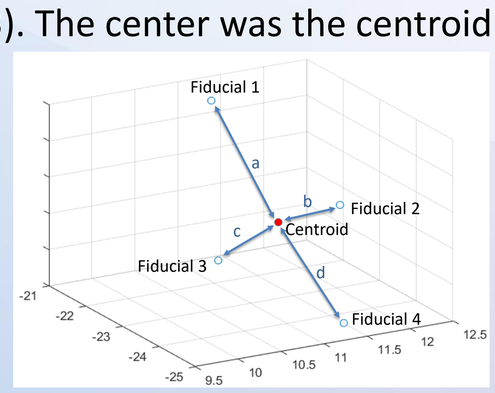
Fig.1 Fiducial implantation



Fig.2 CT scan at exhale breathing status

The MIM software suite (MIM Software Inc., Cleveland, TN) was used to contour the fiducial markers for each of the patient's post-implantation and planning CT images. Each marker was represented as a point at the coordinates of its center of mass calculated by MIM. The coordinates of fiducial markers were entered and analyzed in the MATLAB mathematical package (The MathWorks Inc., Natick, MA).

As a measurement of stability, average center distances (ACD) of the fiducials as given were computed. The ACD were defined as the average of all Euclidian distances of the fiducials to their center (Fig.3). The center was the centroid of a fiducial configuration.



e.g. ACD = (a +b +c + d)/4

Fig.3 Average center distance (ACD) calculation

Results

85% patients implanted with fiducials treated successfully with fiducial tracking in Cyberknife. No patient suffered from pneumothorax after fiducial implantation.

The retention rate of implanted fiducials was 79.2%. By comparing the percentage difference of ACDs between post-implantation and planning day of each patient, relative migration of retained fiducials was found to be 0 to 12.2% (Fig.6). The average fiducial usage rate (tracked/planned) was 75%.

6 degrees of freedom (DOF) correction tracking in Cyberknife requires at least three fiducials to be tracked. 25% patients implanted with 4 fiducials and 60% patients implanted with 5 fiducials successfully treated with 6DOF correction tracking. 100% patients implanted with 6 fiducials successfully treated with 6DOF correction tracking.

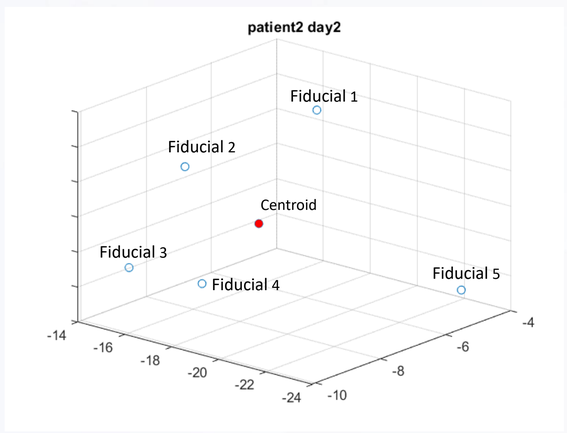


Fig.4 Patient 2 Day 2 fiducial configuration

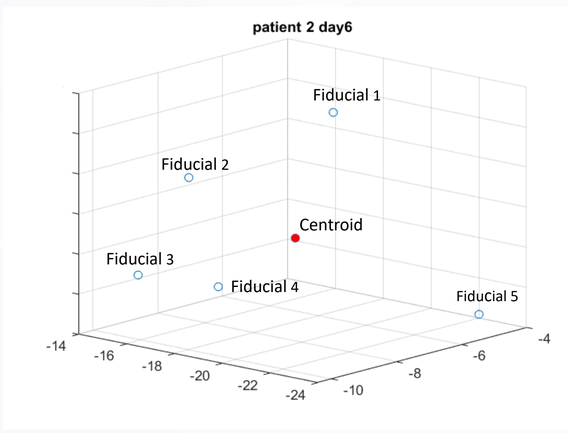


Fig.5 Patient 2 Day 6 fiducial configuration

	ACD Day2 (cm)	ACD plan day (cm)	Relative migration
Patient 1	3.56	3.30	7.30 %
Patient 2	3.83	3.77	1.57 %
Patient 3	3.12	2.74	12.18 %
Patient 4	2.30	2.38	3.48 %
Patient 5	1.80	1.82	1.10 %
Patient 6	4.57	4.60	0.66 %
Patient 7	3.71	3.72	0.27 %
Patient 8	1.74	1.74	0.00 %
Patient 9	3.49	3.56	2.01 %
Patient 10	2.48	2.62	5.65 %
Patient 11	3.24	3.26	0.62 %
Patient 12	3.35	3.48	3.88 %
Patient 13	3.00	2.96	1.33 %

Fig.6 Table of ACD and relative migration

Conclusions

Our results showed that 85% lung cancer patients implanted with fiducials successfully completed SBRT with fiducial tracking in Cyberknife using this workflow. The insertion of fiducials using transbronchial approach was safe and free from complication of pneumothroax.

The retention rate of fiducials was comparable to other international studies. The results suggested the successful rate of using 6DOF correction tracking was highest with implantation of 6 fiducials.

For further information, please contact:
Ms Chloe Chan, Senior Radiation Therapist, Department of Radiotherapy, Hong Kong Sanatorium & Hospital; email: chloe.yy.chan@hksh.com

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