Stereotactic Body Radiotherapy using a new real-time tumor tracking system and fiducial markers

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Introduction

A new fluoroscopic real-time tumor tracking system SyncTraX FX4 (Shimadzu Co. Kyoto, Japan) is comprised of 4 sets of fixed X-ray tube and FPD (Fig 1). This system recognizes the presence of fiducial markers from 2 directions and enables that transmits an irradiation permission signal to a treatment device while a fiducial marker is within a target and stops transmission when it comes off (Fig 2). Using pattern matching score, this system secures position precision quantitatively (Fig 3). With this system, we can reduce the irradiation volume of normal tissue while guaranteeing the positional accuracy of the tumor even under free breathing and improve the patients' burden and adverse events.

Fig 1: SyncTraX FX4

Fig 2: transparent image of SyncTraX

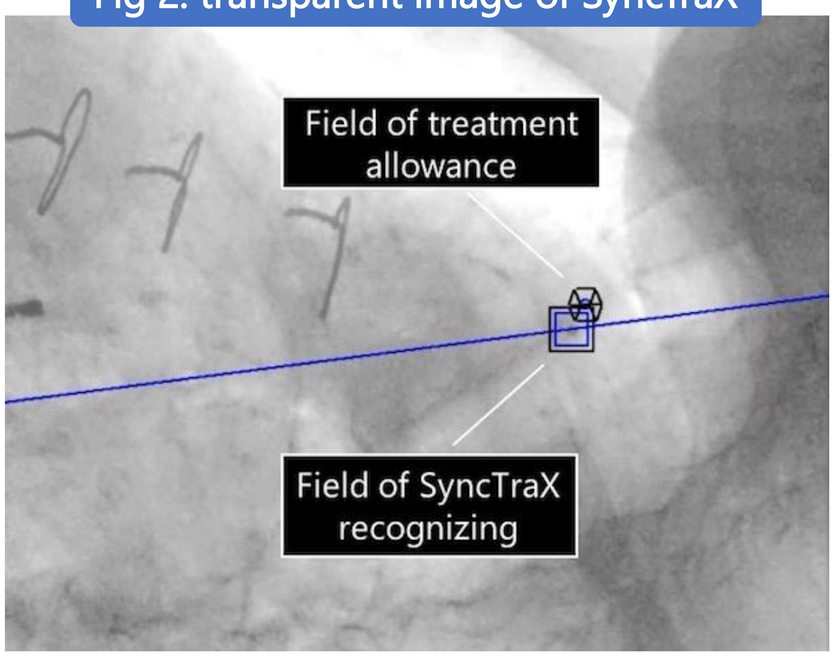
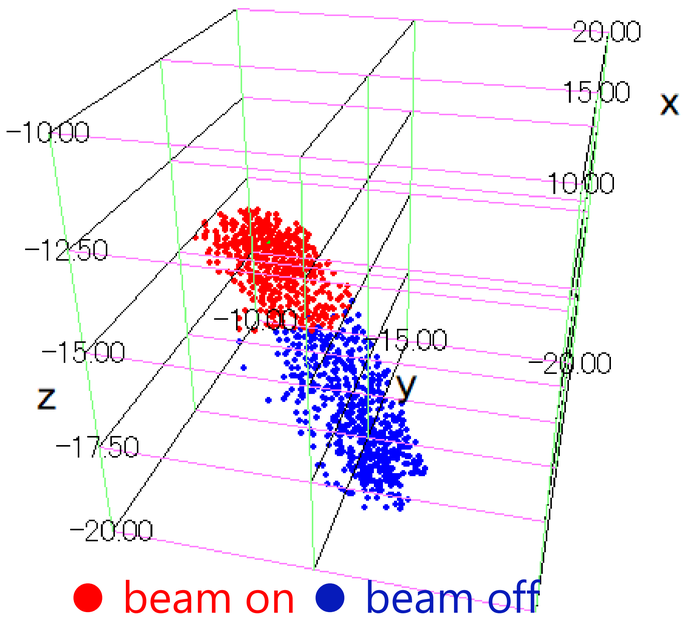


Fig 3: marker position during treatment



Purpose/ Objective

We report the safety and the feasibility of the stereotactic body radiotherapy (SBRT) using this system.

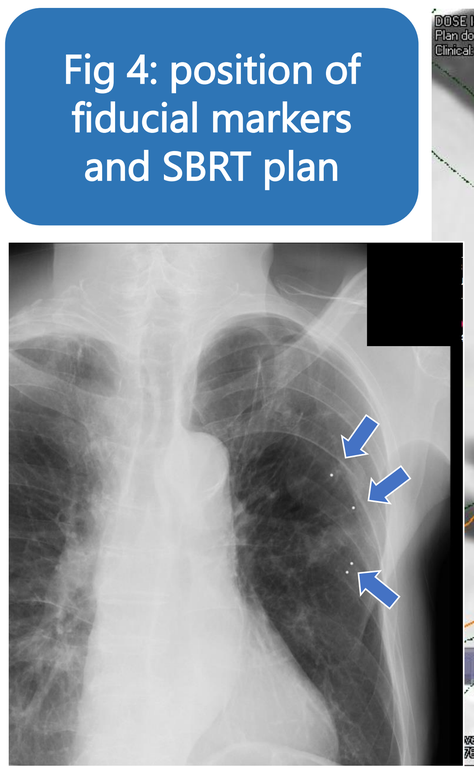
Material/ Method

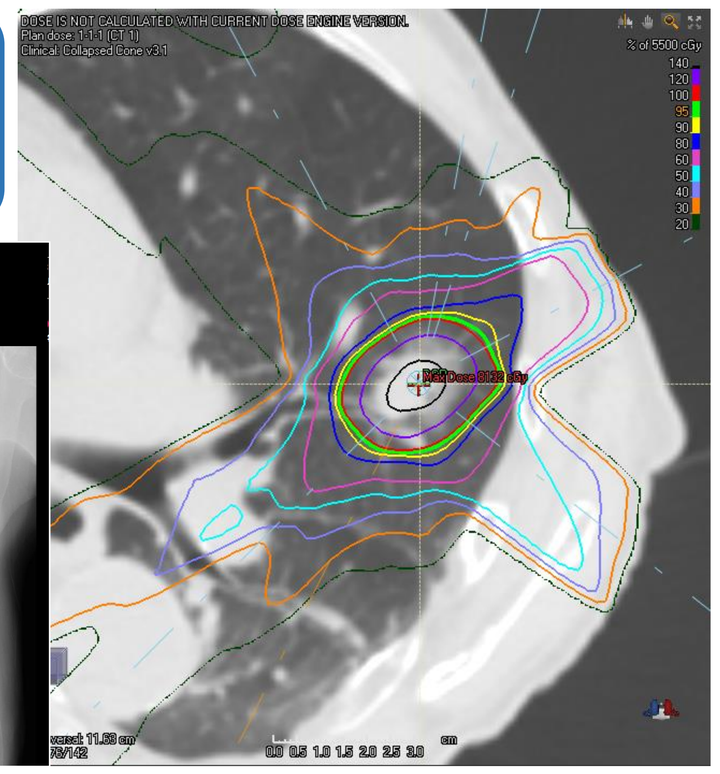
A total of 8 patients and 9 sites treated in our institute between October 2017 and June 2018 were retrospectively reviewed (Table 1). This study included 5 men and 1 woman, whose age ranged from 66 to 83 years (median 71 years). Treated organs were lung: liver was 3: 3, and 3 primary tumors and 3 metastatic tumors each. Fiducial markers were inserted before the treatment planning CT scan; namely Visicoil (SCETI MEDICAL LAB, Tokyo, Japan) to the liver and Disposable Gold Marker (Olympus Co. Tokyo, Japan) to the lung. TrueBeam STX was used as the treatment device, and irradiation method was fixed multiple irradiation. Prescribed dose was 55.0 Gy/ 4 fr or 66.0 Gy/ 10 fr (D95 prescription), planned with RayStation.

Table 1: patients characteristics

	Primary organ	Irradiated site		Total dose / fraction	beam	Breath control
1	Lung	Lung	Left-upper lobe	55.0Gy/ 4fr	6MV FFF	free
2	Lung	Lung	Right-upper lobe	55.0Gy/ 4fr	6MV FFF	free
3	Lung	Lung	Right-upper lobe	55.0Gy/ 4fr	6MV FFF	free
4	Lung	Lung	Left-lower lobe	55.0Gy/ 4fr	10MV FFF	free and exhale hold
5	Lung	Lung	Left-upper lobe	55.0Gy/ 4fr	6MV FFF	Inhale hold
6	Lung	Lung	Right-lower lobe	55.0Gy/ 4fr	6MV FFF	free
7	Lung	Liver	S7	60.0Gy/ 10fr	10MV FF	Inhale hold
8	Extra hepatic bile duct	Liver	S1	55.0Gy/ 4fr	10MV FFF	Inhale hold
		Liver	S6	55.0Gy/ 4fr	10MV FFF	Inhale hold

Fig 4: position of fiducial markers and SBRT plan

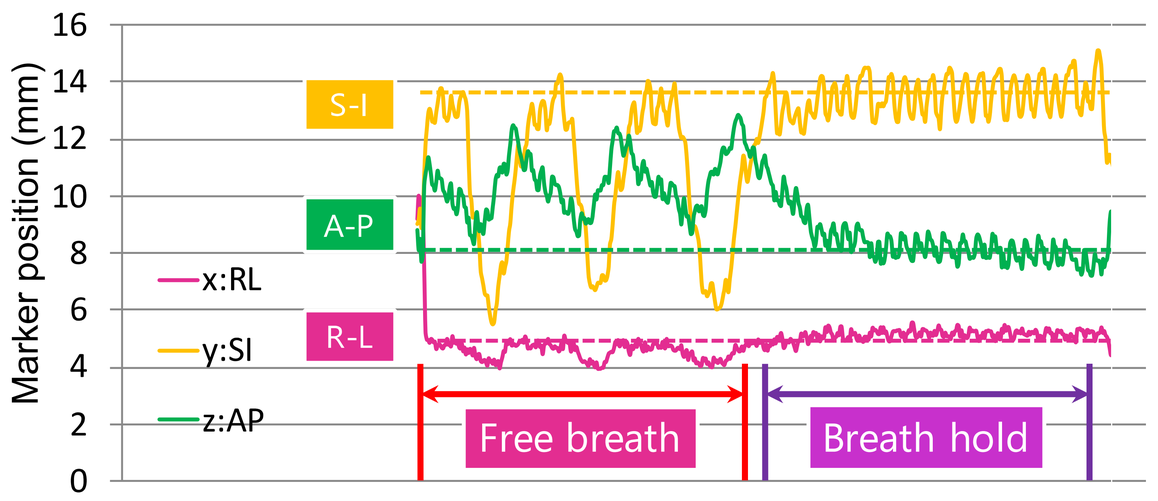




Results

Tumor volume and PTV volume were ranged 4.12cc – 60.01cc (median 13.29cc), and 9.82cc- 115cc (median 33.9cc), respectively. The conformity index (CI) in each irradiation field was 0.82 - 0.9, and the median value of CI was 0.86. Follow-up period was 2.3 – 8.8 (median 5.1) months, and no serious adverse events related to radiotherapy and inserting fiducial markers were observed during the period. Local recurrence was observed in 1 patient, and distant metastasis was observed in 1 patient.
Although a treatment was based on free breathing, it was able to shorten patient radiation exposure and treatment time by using in combination with respiratory arrest system and holding breath. In the liver, because of difficulty to follow fiducial markers depending on some directions, there were cases which needed a change of treatment plan.

Fig 5: three-dimensional movement of fiducial markers



Discussion

Previously, patients who treated with SBRT should hold breath for accuracy in our institution. Holding breath is a good and simple method for improving accuracy. However, almost patients who are treated by SBRT are medically inoperable, that means they have problems on treatment like over age, poor ADL, low respiratory function, and so on. On SBRT planning, we should have added more internal margin for such patients.
After installing SyncTraX FX4 in our institution, such patients also could be treated by high precision SBRT, even with free breath. In other words, we could supply precision radiotherapy for more patients than before.
From three-dimensional trace of the fiducial markers, we found that respiratory movement of tumor was complicative, and largest direction was superior - inferior even in holding breath period (Fig 5).
From some directions, there was a scene where continuous recognition of fiducial markers was difficult by SyncTraX. Before using clinically, we found tracking rate of SyncTraX was made worse by not only thickness but also difference of density like between lung and liver. So in the case of SBRT for abdominal malignant tumors such as liver, it is necessary that a careful meeting with other departments on the position of marker insertion.
There are some weakness of SyncTraX. First, we have to insert fiducial markers. Second, patients must be exposed to X-ray excessively. Third, we cannot use X-ray of SyncTraX and linac's photon beam at the same time, so dose rate is halved to normal (e.g., 10MV FFF 2400MU→1200MU) and it cannot used with VMAT. But in 2019, by update of SyncTraX FX4, it will be possible soon.

Conclusion

SBRT with a real-time tumor tracking system and fiducial markers was a safe and less burdensome treatment.

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Clinical track: Lung

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