

On-line image guided hypofractionation of a solitary lung metastasis using Elekta Synergy®

Institution:	West China Hospital, Sichuan University, PR China
Patient:	47-year-old male
Diagnosis:	Low-differentiated adenocarcinoma of the lung, isolated metastasis in the left upper lobe
Treatment plan:	Elekta PrecisePLAN® IMRT
Image guidance:	Elekta VolumeView™ on-line correction
Positioning:	Elekta Stereotactic Body Frame® and Elekta Active Breathing Coordinator™
Treatment:	Target – 7Gy daily (total 49Gy in 14 days) prescribed to the 80% isodose line



On-line image guided hypofractionation of a solitary lung metastasis using Elekta Synergy[®]

Radiation Oncologist: **Feng Xu MD, Hong Zhang MD., Jin Wang MD., Yali Shen MD.**
Medical Physicist: **Sen Bai MS., Xiaoqin Jiang, Renming Zhong, Qingfeng Xu, Xiaoyu Li, Qingfeng Jiang**

Patient diagnosis and history

A 47-year-old male previously treated for adenocarcinoma of the right upper lung presented with a metastasis in the lingua segment of the left upper lobe in March 2006. The metastasis was diagnosed using a contrast enhanced CT scan. The patient was evaluated and elected to proceed with a course of image guided hypofractionated stereotactic radiation therapy.

The patient was first diagnosed as having a low-differentiated adenocarcinoma of the right upper lobe of the lung (stage IIIA) in March 2004 with the primary tumor in the upper apical-posterior segment of the right lung, right hilum, and an upper mediastinal lymph node metastasis. The patient was treated with right upper lung lobectomy and mediastinal lymph node dissection followed by adjuvant alternate chemotherapy (vinorelbine 40mg iv drip, days one and eight, cisplatin 50mg, IV drip, days one to three – 21 days per cycle for a total of four cycles) and radiation therapy.

Previous radiation therapy

The mediastinum region from the level of the thoracic inlet to 5cm below the carina, the right hilum, and the right supraclavicular fossa had received adjuvant radiotherapy of 50Gy in 25 fractions in May 2004.

Planning and treatment

Patient characteristics and radiation therapy prescription are listed in tables 1 and 2.

Table 1: patient characteristics

Age	47
Gender	Male
Histology	Low-differentiated adenocarcinoma
Location of tumor	Left upper lobe of the lung
Primary or metastasis	Metastasis
Primary tumor	Right upper lobe of the lung
Size of the tumor	1.5 × 1.5 cm

Table 2: summary of treatment

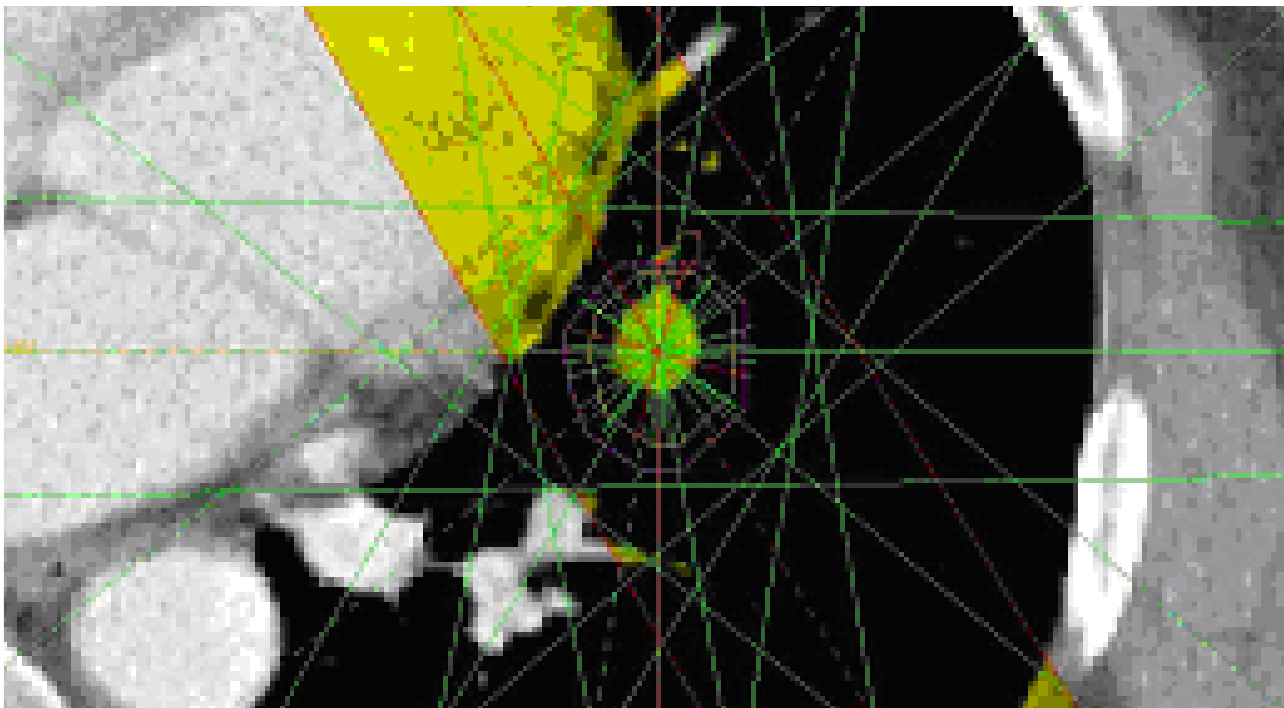
Characteristics	Number
Total dose (80% isodose line)	49Gy
Number of fractions	7
Number of beams	7
NTD* ($\alpha/\beta=10$) (80% isodose line)	69.4Gy
Overall treatment time	14 days

*2Gy biologically normalized total dose

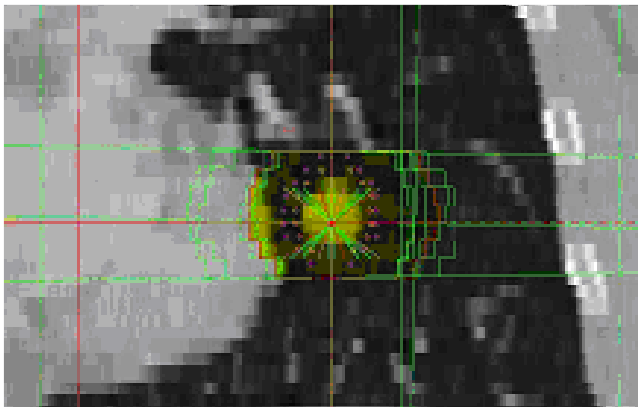
A planning CT scan with 3mm-cuts of the whole thorax was taken, with the patient in the treatment position, using Active Breathing Coordinator™ to achieve a deep inspiration breath hold and Stereotactic Body Frame® for immobilization.

GTV was defined on the CT image using the lung image display window. CTV was defined as GTV plus 3mm margin and PTV was CTV plus 3mm uniform margin in three-dimensions. A 3D conformal RT plan was generated using PrecisePLAN® Release 2.10.

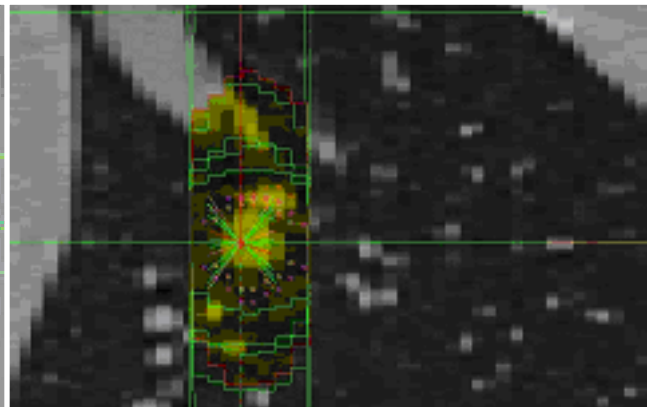
The tumor was irradiated with 6MV photons using a seven-field beam arrangement (figure 1). The prescribed dose was 49Gy at 7Gy per fraction to the 80% isodose line, normalized to the isocenter. The 2Gy biologically normalized total dose (NTD2Gy) at 80% isodose line was 69.4Gy and 86.7Gy at isocenter assuming $\alpha/\beta = 10$. The mean dose in GTV was 56.54Gy (55.46Gy ~ 58.05Gy), the mean dose in CTV was 56.31Gy (52.2Gy ~ 58.12Gy), mean dose in PTV was 55.6G (39.85Gy ~ 50.18Gy). The maximum dose for left inferior lingular bronchial vessel was 58.18Gy. Dose to the spinal cord was restricted (max. dose 59.8Gy) due to the previous exposure of the spinal cord to a maximum of 40Gy 24 months earlier – figure 2 shows the DVHs of organs of interest.



A: transverse section



B: coronal section



C: sagittal section.

Figure 1: contouring of GTV, CTV, PTV and critical organs-at-risk via PrecisePLAN® Release 2.10.

Key	Structure	Plan	Min Dose (cGy)	Max Dose (cGy)	Mean Dose (cGy)	%
—	STV	Shanghong-1829-Shouxuewen-lung(04)	5546	5805	5654	
—	R. Lung	Shanghong-1829-Shouxuewen-lung(04)	2	511	55	
—	L. Lung	Shanghong-1829-Shouxuewen-lung(04)	3	5819	399	
—	Cord	Shanghong-1829-Shouxuewen-lung(04)	4	598	166	
—	Heart	Shanghong-1829-Shouxuewen-lung(04)	48	4533	423	
—	Bronchus Ligular	Shanghong-1829-Shouxuewen-lung(04)	448	5658	4373	
—	cTV	Shanghong-1829-Shouxuewen-lung(04)	5220	5812	5631	
—	PTV	Shanghong-1829-Shouxuewen-lung(04)	3985	5818	5562	

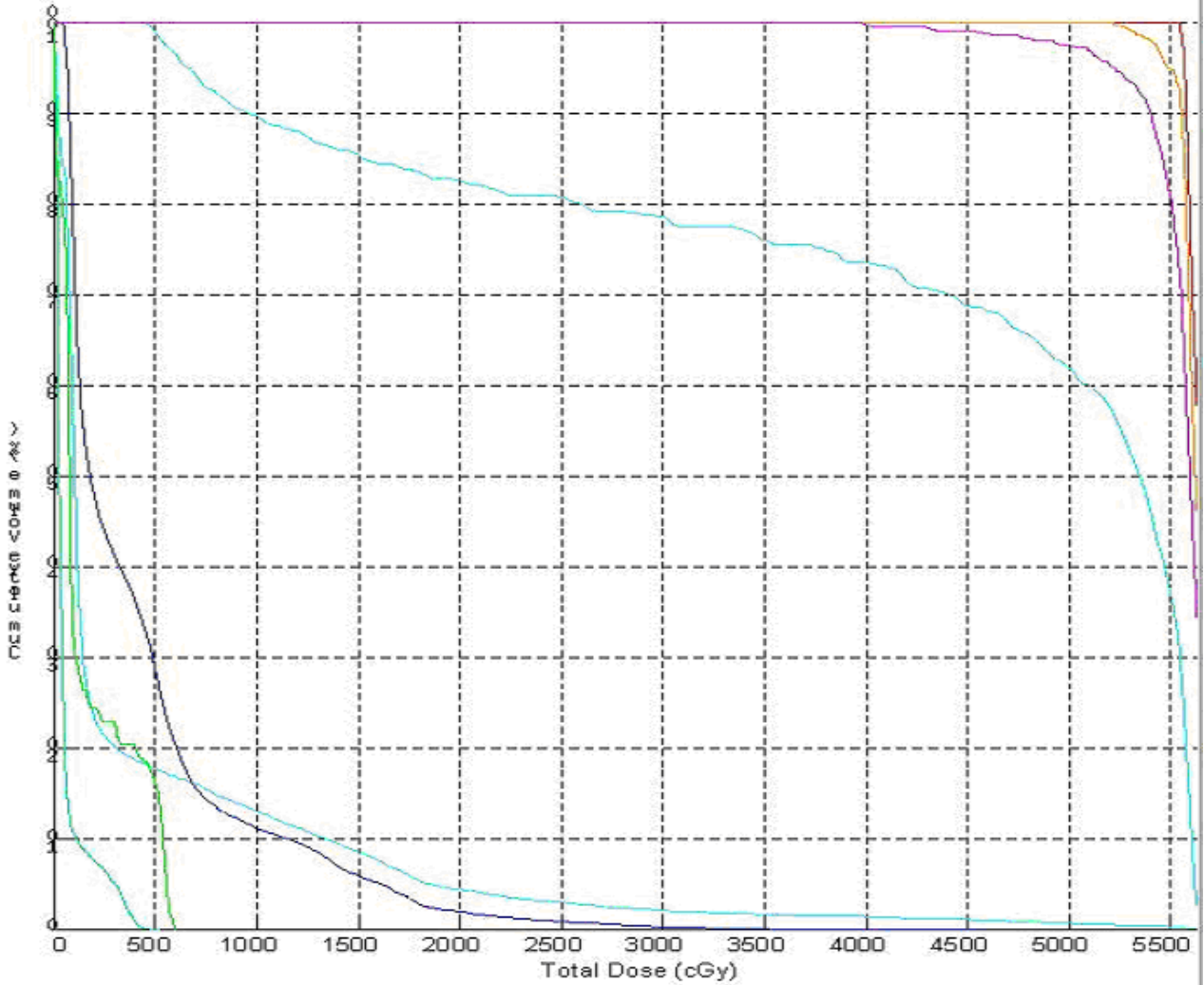


Figure 2: DVH for a seven-field 3D IMRT plan with limited dose to the surrounding lung, heart, large blood vessels and spinal cord.

The patient was immobilized with a combination of Stereotactic Body Frame® and Active Breathing Coordinator™ using a 20-second breath hold. Daily position localization and correction were performed on-line using VolumeView™ imaging on Elekta Synergy®. VolumeView™ imaging was acquired daily prior to and following patient position correction, and then again immediately after treatment delivery. The position before correction is shown in figure 3 from A to C, after correction D to F, and after treatment G to I. Statistics of daily targeting position in relation to planned isocenter are shown in Table 3. The significance of difference in target localization before and after position correction and after treatment was analyzed using F-test (one-way ANOVA). $P < 0.05$ is considered statistically significant.

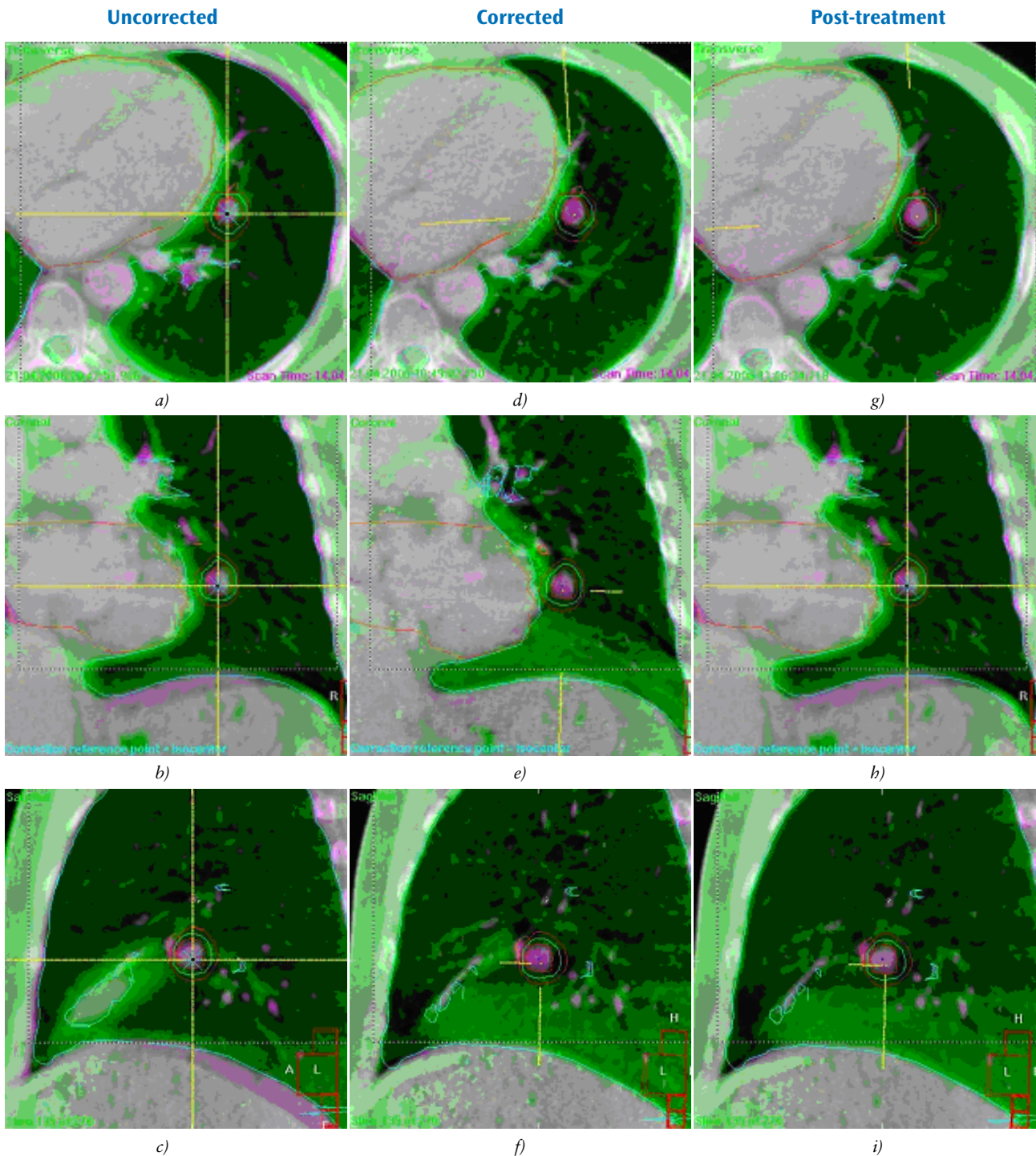


Figure 3: VolumeView™ images taken using Elekta Synergy® with structure overlay from the planning reference image. Images a, d and g show axial positioning prior to and after correction drawn from the table correction vectors produced by the XVI software. Images b, e and h show coronal positioning before and after correction and after treatment. Images c, f and i show sagittal positioning before and after correction and immediately after treatment.

2 to 3 mins.	– patient set-up
1 to 2 mins.	– acquisition and reconstruction
1 to 2 mins.	– image registration
1 to 2 mins.	– positional correction, on-line

Post correction	
3 mins.	– imaging and registration, on-line

~ 20 mins.	– IMRT treatment time
5 to 8 mins.	– post treatment to image and review, off-line

Direction	Pre-correction mean \pm SD (cm)	Post-correction mean \pm SD (cm)	Post-treatment mean \pm SD (cm)	P *
Left-right	0.25 \pm 0.07	0.09 \pm 0.11	0.10 \pm 0.09	= 0.009**
Anterior-posterior	0.29 \pm 0.17	0.13 \pm 0.15	0.10 \pm 0.09	= 0.134
Cranio-caudal	0.13 \pm 0.12	0.13 \pm 0.14	0.10 \pm 0.10	= 0.878

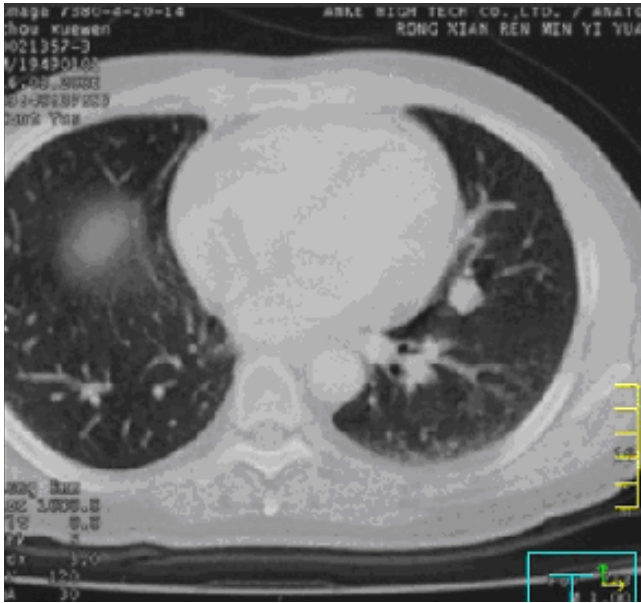
Table 3: absolute positioning errors detected by CBCT

* One-way ANOVA

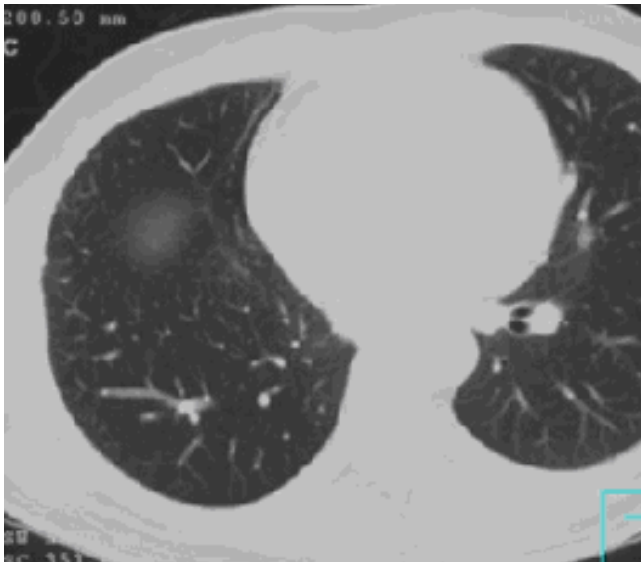
** Post Hoc contrast between groups: at lateral direction, pre-correction error is significantly higher than post-correction ($p=0.012$) and post-treatment position ($p=0.006$), but no significant difference between post-correction and post-treatment relative position ($p>0.05$).

Outcome and follow-up

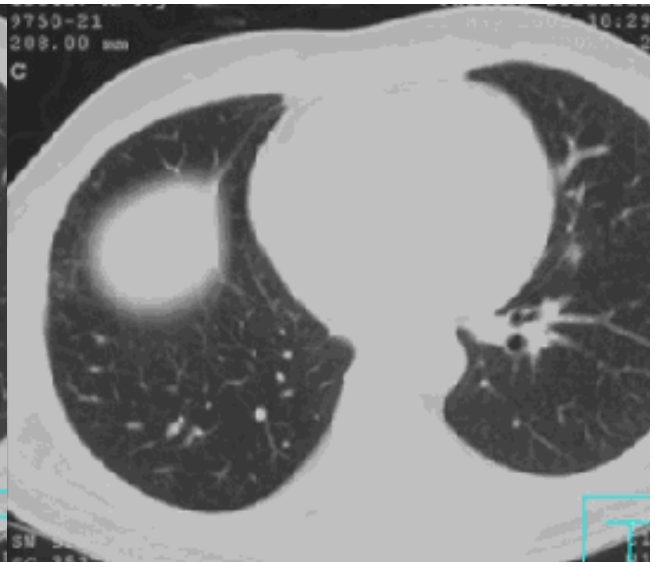
Follow-up CT scan was performed one month after radiation therapy was completed. The tumor showed marked regression (Figure 5). There was no evidence of radiation pneumonitis on CT scan. At the time of writing this case study, the patient has no symptoms and no signs of tumor progression or toxicities.



A: before treatment



B: after treatment



C: after treatment

Figure 5: CT scans before and after radiation therapy. A: before treatment, B and C: after treatment.

Discussion

Highly conformal 3D radiation therapy using tight margins allows a large dose per fraction for a small and solitary pulmonary malignancy. However, it has to be achieved using a highly integrated image guided therapy system. This report includes our first patient treated using the on-line VolumeView™ radiation image guided technique. It demonstrates a successful treatment of lung cancer using hypofractionation and advanced integrated technologies, such as Stereotactic Body Frame® and Active Breathing Coordinator™ for immobilization, and 3D volume imaging for target localization and correction. The study shows a clinical feasibility of online image guidance in a routine clinic.

Acknowledgements

The authors would like to thank Dr. Di Yan, the Director of Clinical Physics, Radiation Oncology, William Beaumont Hospital, Royal Oak, Michigan, USA for his helpful instruction.

Fighting serious disease

www.elekta.com

■ Stereotactic Neurosurgery ■ Gamma Knife® surgery ■ Functional Mapping ■ Precision Radiation Therapy ■ Image Guided Radiation Therapy ■ Stereotactic Radiation Therapy

Corporate Head Office
Stockholm, Sweden
Tel +46 8 587 254 00
Fax +46 8 587 255 00
info@elekta.com

**Worldwide Product
Support Center**
Tel +44 01293 654068
Fax +44 01293 654655
info.europe@elekta.com

North America
Atlanta, USA
Tel +1 770 300 9725
Fax +1 770 448 6338
info.america@elekta.com

**Europe, South America,
Africa & the Middle East**
Tel +44 1293 654068
Fax +44 1293 654655
info.europe@elekta.com

Japan
Kobe, Japan
Tel +81 78 241 7100
Fax +81 78 271 7823
info.japan@elekta.com

Asia-Pacific
Hong Kong, China
Tel +852 2891 2208
Fax +852 2575 7133
info.asia@elekta.com