The quantification of delivered IMRT dose distributions for mobile targets.

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Background

●Degradation of dosimetric coverage of mobile tumor volumes can occur with MLC based IMRT.

●The planned vs. delivered dose discrepancy may be secondary to the interplay between the dynamic delivery of the radiation and the respiratory motion of the tumor.

●We hypothesize that using an ITV planning approach coupled with compensator based IMRT will result in better agreement between the planned and delivered dose distributions.

Materials/Methods

•MLC and compensator-based IMRT plans were generated in Pinnacle treatment planning system (TPS) for a series of previously treated patients (5 pancreatic, 5 esophageal, and 4 liver cases). The PTV coverage and OAR sparing were matched yielding nearly identical DVHs.

•The dose distributions were measured with a bi-planar diode array dosimeter (Delta 4, ScandiDos AB, Uppsala, Sweden). The dosimeter was placed on an acrylic table manufactured and programmed for two dimensional motion. The motion platform moved on an engraved ramp with a 10° inclination and a motion pattern that was determined from a 4D CT of an esophageal case.

•For the specific data set presented, motion was varied by amplitude (24, 14.5, 10, and 6 mm) while frequency remained at 12 cycles per minute. (Figure 1)

•Gamma analysis, using a 3% - 3mm passing criteria, was performed by using motion measurements as the target dose and static measurements as the reference dose.

•Reproducibility of results were checked for 15 cases with 15 motion measurements to assess the variation caused by varying the phase between the motion and delivery.

•The effects of dose averaging were evaluated over 5, 10 and 15 deliveries for 15 cases

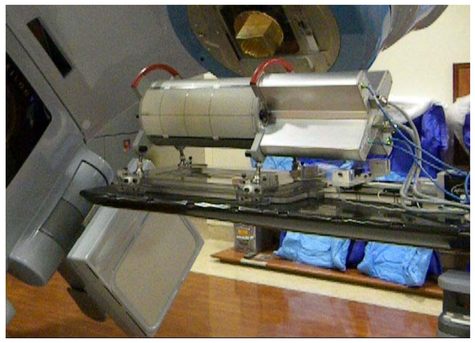


Figure 1 The delta 4 on our motion table

Results

•15 patient plans generated with both compensators and MLCs

•4 Liver, 6 Esophagus, and 5 Pancreas cases

•Motion of 24, 14.4, 10, and 6 mm

•Period of 5 seconds and static cases were measured

•To eliminate the differences between the agreement between plan and static delivery, delivered doses were compared to the static delivery on a diode by diode basis

•Statistics were calculated using the paired t-test comparing single fraction delivery

•Liver case example shown below:↓

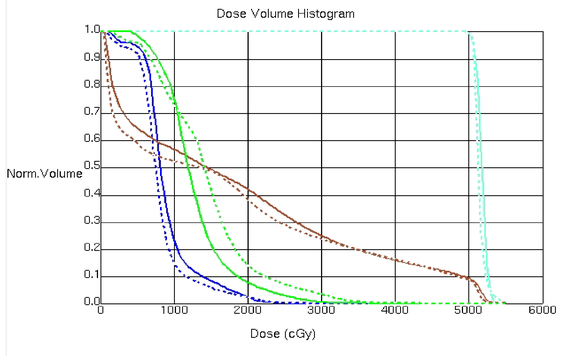


Figure 2 DVHs for the example liver case.
Dotted: Compensators Smooth: MLC

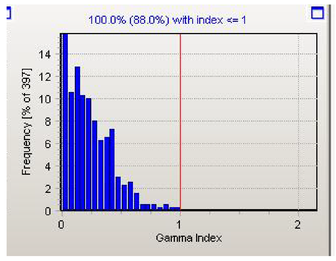
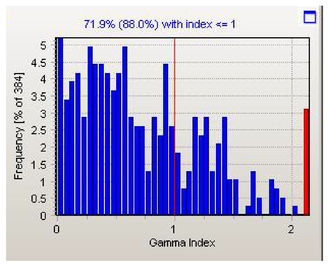
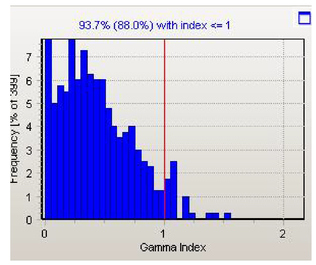


Figure 3
3%/3mm Gamma analysis for a static delivery for this case.

To avoid biasing the results, all measurements with motion were compared to static measurements for the same delivery method.

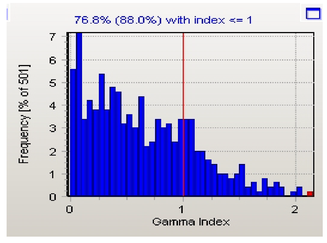


MLC delivery

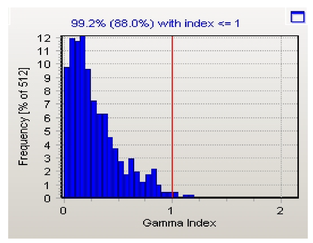


Compensator Delivery

Figure 4 3%/3mm Gamma analysis for 2.4 cm of motion



MLC delivery



Compensator Delivery

Figure 5 **3%/3mm Gamma analysis for 1.0 cm of motion**

Table below shows results with the average number of points passing the Gamma 3%/3mm criteria followed by the Standard deviation in brackets.

Motion	COMPS %Agreement	MLC %Agreement	P Value
24 mm	95.6 (1.6)	86.8 (3.8)	0.003
14.4 mm	99.0 (1.3)	93.6 (2.0)	0.031
10 mm	100 (0.02)	97.5 (3.0)	0.036
6 mm	100 (0.01)	99.0 (0.2)	0.005

Reproducibility

●The phase between motion and delivery can change the results.

●One liver, esophagus and pancreas case were re-measured for 15 fractions.

●Dose averaging was also done over 5, 10 and 15 fractions.

●We present here the 15 fraction data:

	Average passing	STD	Range
Liver			
COMPS	93.7%	0.7%	92.2-94.7%
MLC	75.1%	8.1%	61.7-85.0%
Dose Averaging			
COMPS	96.7%		
MLC	88.3%		
Esophagus			
COMPS	95.1%	0.5%	94.2-95.9%
MLC	84.7%	3.6%	78.6-89.6%
Dose Averaging			
COMPS	94.5%		
MLC	86.4%		
Pancreas			
COMPS	98.3%	1.1%	95.5-99.4%
MLC	69.0%	10.6%	37.9-81.3%
Dose Averaging			
COMPS	98.3%		
MLC	91.6%		

Conclusion

●Our data shows that MLC based IMRT is associated with significant dose degradation if respiratory associated target motion exceeds 1cm.

●Compensator based IMRT can significantly improve dose delivery in the setting of target motion greater than 1cm.

●Although dose averaging may blur the effect of such motion, the end result is still to have significantly less concordant dose delivery with MLC based IMRT than with compensator based.

●If respiratory target motion exceeds 1 cm, an MLC based IMRT technique should not be utilized.

MKT 321

MOFFITT CANCER CENTER

Radiation Oncology

IMRT For Mobile Targets

According to a recent study conducted by Moffitt Cancer Center, if the tumor motion is 1 cm or larger…

- *Compensator-based IMRT yields a clearly superior delivery when compared to MLC-based IMRT*
- *The delivered dose distribution for **MLC-based IMRT can be off substantially with up to 60% of the measurements failing**! Typically 25% of the measurements failed*
- ***The delivered dose distributions for compensator-based IMRT were significantly superior** with the same motion, with 20% of the points failing in the worst case and on average ~5% of the points failed*
- *Even with averaging over 15 treatments compensator-based IMRT dose distributions are significantly closer to the planned dose distributions*
- *At the Moffitt Cancer Center, IMRT patients with tumor motion of 1 cm or larger are treated with compensators*

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