AbstractID: 9321 Title: Application of 5D breathing motion model for monitoring radiation damage

Purpose: To present a novel method for monitoring radiation damage using the parameters of our 5D lung motion model.

Method: The 5D breathing motion model describes breathing motion as a function of tidal volume *v* and airflow *f* and is parameterized as: $\mathbf{r} = \mathbf{r}_0 + \boldsymbol{\alpha} v + \boldsymbol{\beta} f$, where **r** is the position of a piece of tissue located at reference position $\mathbf{r}_0$. **α** and **β** are each functions of $\mathbf{r}_0$ and relate tissue motion with tidal volume and airflow. The continuity equation $\mathrm{Div}(\rho \mathbf{U}) = -d\rho/dt$, where ρ is the local density, *t* is time, and **U** is the velocity field, is modified to replace tidal volume as the independent variable. At inhalation or exhalation, the $f=0$ and under these conditions, the continuity equation leads to $\mathrm{Div}(\boldsymbol{\alpha}) = -1/\rho * d\rho/dv$ in the tissue reference frame. This equation provides the relationship between the divergence of **α** and the relative change in local tissue density. The powerful aspect of this result is that the **α** parameter is determined using free-breathing scan registrations which inherently include the complex hysteresis interplay, and yet its divergence indicates the local relative density change as a function of tidal volume. The values of **α** were determined for repeat 5D CT scans for both irradiated and unirradiated lungs.

Result: The unirradiated patient had little change in the value of **α** between two scan sessions. A lung cancer patient had 5D CT scans acquired after 16 Gy and 70 Gy tumor dose. The value of **α** changed dramatically in the irradiated regions. This result indicates that **α** is sensitive to radiation dose damage.

Conclusion: The divergent of **α** is shown to be related to the relative local density variation as measured using free-breathing 5DCT. Repeat scans indicate that variations in the **α** distribution, corresponding to changes in local density variations, may be sensitive to local radiation damage.