Design and verification of a heterogeneous proton equivalent thorax phantom for use in end-to-end assessment of pencil beam proton therapy

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Purpose

To implement a phantom that can assure institutions can deliver clinically comparable and consistent radiation doses in proton therapy for lung cancer.
Current phantom

(Blatnica, 2011)  (Followill et al., 2007)
Insert

- Designed to minimize air gaps
- High impact polystyrene target and shell
- Balsa surrounding
- Three film planes, two TLD
Determination of bone equivalent material

\[ RLSP = \frac{\left( R_{80,w} - R_{80,m} \right)}{t_m} \]
Design of phantom
Insert motion

VMX motion profile

Displacement (mm) vs. Time (s)
Imaging

- 3D CT for breath hold
- 4D CT for free breathing
Treatment Plans

• 4 plans were made
  • PSBH
  • SS2cm
  • PSFB
  • SS1.5cm
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Treatment Setup
Results: TLD
Results: Film

Gamma Index of 5% / 5mm

Pixels Passing (%)

SS2cmC  PSBHC  SS1.5cmC  PSFBC

Treatment Plan Type
Conclusions

• The bone equivalent clay, and other phantom materials were found to simulate anatomy

• A phantom was developed with proton equivalent materials

• The phantom demonstrated the ability to be used as an end-to-end quality assurance tool for the credentialing of proton centers to clinical trials for lung cancer
Future work

• The current target material generated 10% reduction in gamma pass percentages
  • Should be accounted for by replacement
• More irradiations are needed to determine appropriate TLD, film and institution pass criteria
Thank you
MD Anderson proton parameters

- Spill length: 0.5 – 5s (PS)
- Spill length: 0.5 – 4.4s (SS)
- Energy / range resolution: 0.4MeV / 0.1g/cm²
- Spot size: 5 mm – 14.5 mm