DEVELOPMENT AND IMPLEMENTATION OF AN ANTHROPOMORPHIC HEAD AND NECK PHANTOM FOR THE ASSESSMENT OF PROTON THERAPY TREATMENT PROCEDURES

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Hypothesis
An anthropomorphic H&N phantom can be designed and built to evaluate proton therapy H&N treatment procedures that can reproducibly (±3%) assure agreement between the measured doses and calculated doses within ±7%/4mm.

Results

Design and Construction
• Phantom insert was designed with appropriate imageable targets and critical structures that mimicked human anatomical dimensions and the usual extent of oropharyngeal disease, while still accommodating radiation dosimeters.
• The insert was made of solid water. The “horse shoe” shaped target along with the three relevant organs at risk were made of blue water. Both materials are proton tissue equivalent.

Treatment Planning
• A spot scanning treatment plan was created and successfully addressed clinical target and OARs doses, and therefore was approved by a PTC-H physician.
• For the passive treatment plan, the parotids were sufficiently shielded, however, the spinal cord was not protected sufficiently and the target coverage was non-uniform, with several cold and hot spots. The structures chosen to be in the insert, based on actual patient anatomy, were too close together for the passive plan to successfully achieve typical clinical goals.

Point Dose Dosimetry
• Target TLD Ratios showed good agreement between the treatment planning system and the average TLD measurements, 1.6% for the sup. target and 1.4% for the inf. Both target TLD ratios met IROCs acceptance criterion of ±5% dose agreement tolerance.

Relative Dosimetry
• All relevant trials pass the 85% criteria used at IROC for the gamma index proposed in the hypothesis (7%/4 mm). As expected, tighter criteria show lower passing rates, but still perform well, where only Trial 5 sagittal does not pass.

Conclusion
• The target TLD doses were within IROC’s acceptance criterion of ±5% dose agreement tolerance, but low when compared to the TPS calculations. One possible explanation for this outcome could be that proton therapy treatment planning systems tend to overestimate target doses by as much as 3.5% for head and neck patients when compared to Monte Carlo simulations.
• The relative dose distribution analysis was performed using ±3%/3mm, ±5%/4mm and ±7%/4mm gamma index acceptance criteria. All relevant trials pass the 85% criteria used at IROC for the gamma index proposed in the hypothesis (7%/4 mm). As expected, tighter criteria show lower passing rates, but still perform well, where only Trial 5 sagittal does not pass 5%/3mm.
• Moving forward we expect to redesign the insert so that the structures have a larger separation between them. That would be done with the intent to develop a passive treatment plan that could successfully achieve typical clinical goals.

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