Evaluation of a novel CBCT-based dose calculation for lung treatment plans using End-to-End phantom

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INTRODUCTION

Background

- The Nobel TrueBeam HyperSight CBCT (HS-CBCT) system improves HU accuracy and image quality compared to previous systems[1].
- In preparation for introduction of offline ART, it is necessary to evaluate the accuracy of dose calculation using HS-CBCT with a human body phantom.
- To the best of our knowledge, no study has evaluated the dose calculation accuracy of TrueBeam HS-CBCT for lung treatment planning by comparing measured and calculated values derived from various imaging parameters and reconstruction algorithms.

Purpose

- This study evaluated the accuracy of dose calculation using TrueBeam HyperSight CBCT (HS-CBCT) for measured values in lung treatment planning using the End-to-End (E2E) phantom.

METHODS AND MATERIALS

- A CT-ED phantom and an E2E phantom were imaged using HS-CBCT and a planning CT (pCT) system (Aquilion ONE, Canon Medical Systems, Japan).
- HS-CBCT acquisitions and reconstruction algorithms were as show in Table.1.
- CT-ED tables were generated for each imaging parameter set and imported into the Eclipse (AcurosXB v18.0.1, Siemens Healthineers, USA) for dose calculation.
- The calculated doses of 3D-CRT and IMRT for a simulated lung tumor in the E2E phantom were compared with the doses measured using an ionization chamber (Semiflex3D, PTW, Freiburg, Germany).

Table.1 HS-CBCT acquisitions in this study

Tube Voltage (kV)	Tube Currents (mAs)	Reconstruction Algorithm	Slice Thickness (mm)	Trajectory / Filter
125, 140	530, 1060, 1680, 2210	Feldkamp-Davis-Kress (FDK), iterative CBCT (iCBCT), iCBCT with metal artifact reduction (iCBCT MAR)	2.0	Full / Half

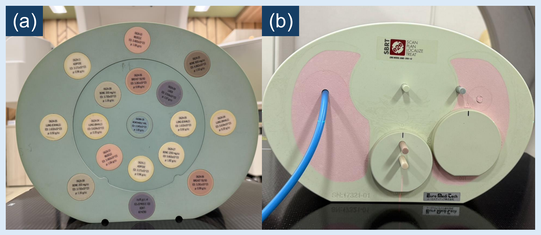


Fig.1 (a) CT-ED phantom (062M, CIRS, USA) and (b) E2E phantom (036S, CIRS, USA)

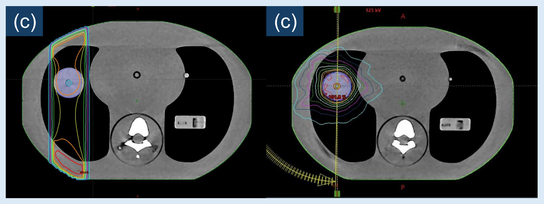


Fig.2 (c) 3D-CRT plan and (d) IMRT plan for a simulated lung tumor in the E2E phantom

RESULTS

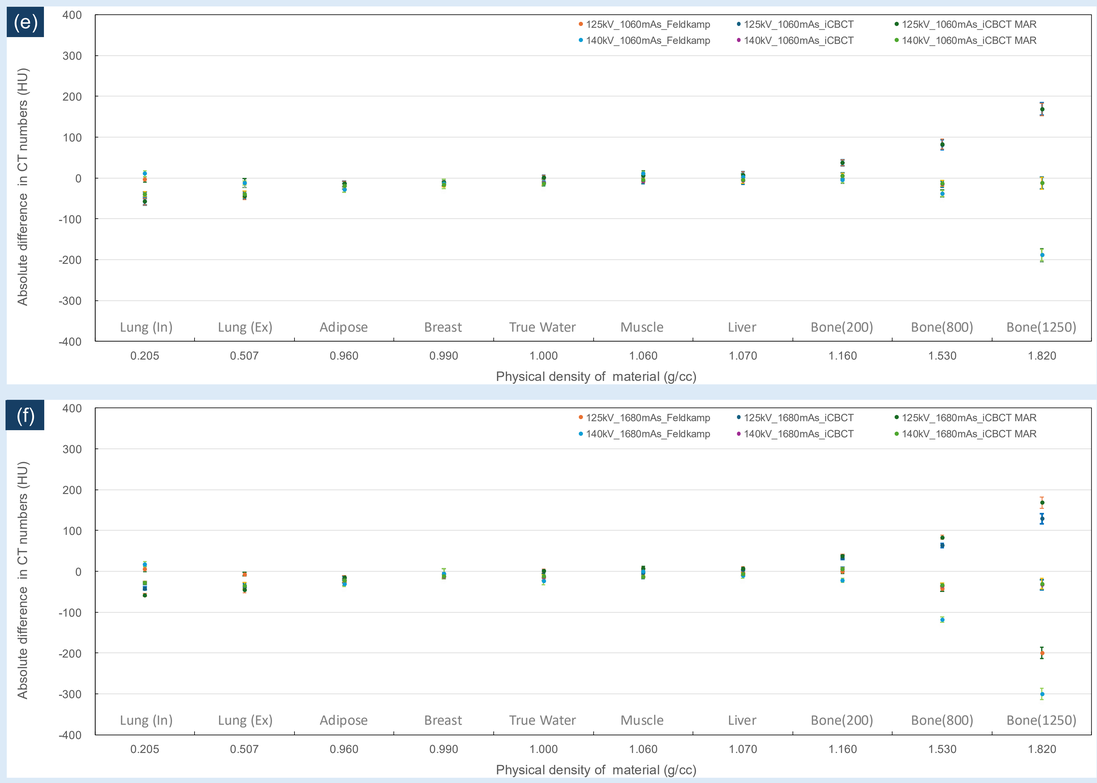
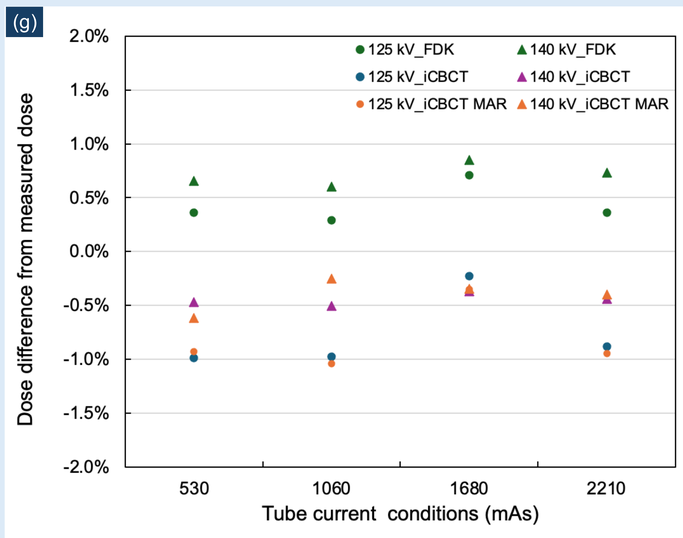


Fig.3 Absolute difference of CT number between HS-CBCT and planning CT for each material plug constituting the CT-ED phantom. The data is the CT value under each condition at (e) 1060 mAs, and (f)1680 mAs.



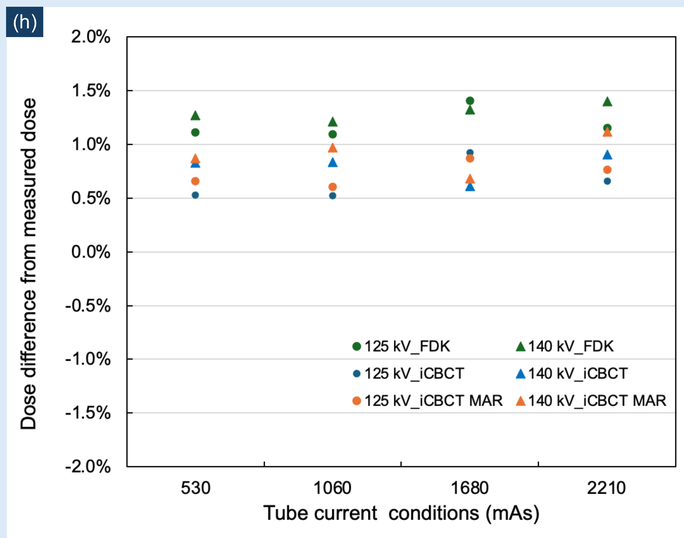


Fig.4 A comparison of the difference dose between the value calculated using the CT-ED table for each imaging parameter set and the measured value. The plots correspond on (g) the 3D-CRT, and (h) IMRT.

- The difference in mean CT values between HS-CBCT and planning CT for each material plug constituting the CT-ED phantom diverged in the high-density region (see Fig.3).
- The dose difference between the calculated and measured values for each plan showed that variations in tube voltage and tube current conditions had little impact (Standard deviation ≤ 0.37%), whereas differences in reconstruction algorithms had the greatest impact on calculation accuracy (see Fig.4).
- For the 3D-CRT plan, the best result was -0.23% at 125kV, 1680mAs, iCBCT. For the IMRT plan, the best result was 0.52% at 125kV, 1060mAs, iCBCT.

DISCUSSION

- This is consistent with previous studies[2,3], including the report by K. Gregg et al[4]., and demonstrates the validity of the CT-ED table obtained using HS-CBCT.
- When the tube voltage was changed using the same reconstruction algorithm, there was only a small fluctuation in the CT value excluding bones, which had an extremely small impact on its accuracy.
- For IMRT plans in particular, the calculated values under the FDK condition were, on average, +1.26% higher than the measured values, whereas the iCBCT condition was, on average, 0.72% higher.
- Only the iCBCT condition had a dose difference of within 1% for all plans, demonstrating high calculation accuracy.

CONCLUSIONS

- The dose calculation accuracy of HS-CBCT using the E2E phantom was within ± 2.0%, and the iCBCT conditions demonstrated dose calculation accuracy within ± 1.0%.
- The Evaluation of this study suggested that dose calculation using HS-CBCT could be clinically applicable for 3D-CRT and IMRT plan for treatment.
- Determining the appropriate imaging conditions will improve CT values for highly absorbent materials, leading to even more accurate results.

REFERENCES

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