Establishing a routine CBCT-based clinical dose verification workflow

G . KUZMIN[1], P. XIA[1], P. QI[1]
1Cleveland Clinic Foundation, Cleveland, OH

JULY 12–16 2020 VIRTUAL
JOINT AAPM | COMP MEETING
EASTERN TIME [GMT-4]

INTRODUCTION

- On-board CBCT imaging is routinely used to verify and correct for patient setup errors
  - If the anatomy deems to be significantly different from the original planning CT, adjustments are made to treatment plans
  - However, it is difficult to ascertain when anatomical differences justify a replan
- This study investigates use of CBCT and log files for continuous dose monitoring and verification

DOSE CALCULATION

- Dose calculation was performed with the Sun Nuclear PerFraction™ software
- If PerFraction™ is setup to be used for routine IMRT QA, ***no additional clinical steps are required***
- PerFraction™ was set up to automatically retrieve and fuse the CBCT dataset to the planning CT
  - The software imports clinical IGRT registration offsets, creating a CT-CBCT merged anatomy
- Log files are used to calculate dose distribution on the CT-CBCT merged patient anatomy

METHOD

1. Quasar cube phantom was used to verify initial image registration accuracy
2. Head and neck portion of a RANDO phantom was used to test full process from simulation to treatment
   1. Scanned phantom using sim CT, Iso was placed
   2. Planned a faux partial brain treatment with 2 arcs
   3. Followed clinical IMRT QA procedure
   4. Delivered treatment and analyzed results
3. Preliminary analysis was performed on 10 partial brain patients
   1. Dose calculated on planning CT
   2. Dose recalculated using log files on CT-CBCT merged anatomy
   3. Difference analyzed between the two datasets

RESULTS

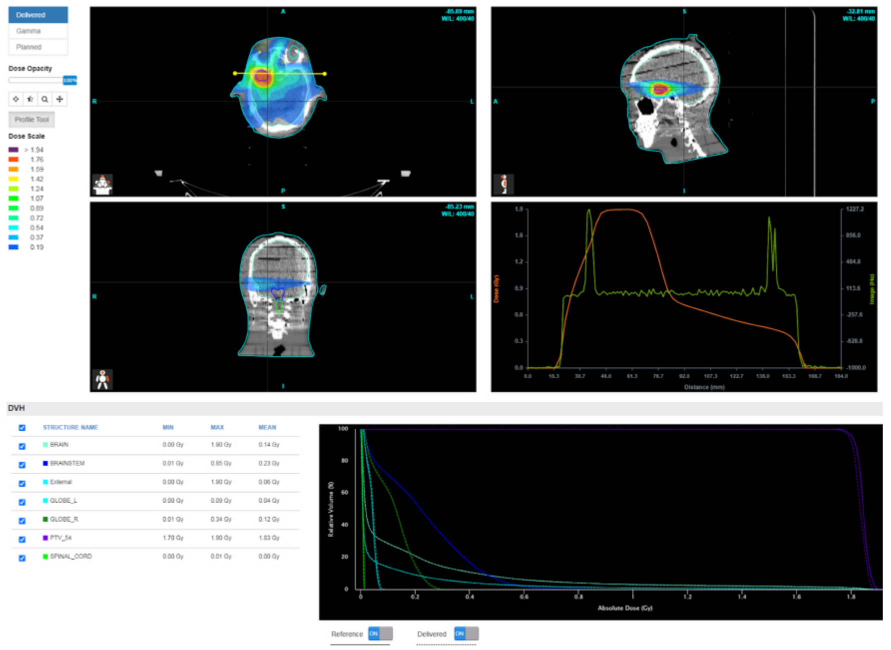
The PerFraction™ software was able to accurately register the Quasar and RANDO phantom anatomies between the planning CT and CBCT images after deliberate shifts to the treatment position were introduced.

Using the PerFraction™ software, it is possible to monitor and compare
- PTV min/max/mean doses
- OAR min/max/mean doses
- DVH prescription/delivered dose difference
- Other metrics such as 3D gamma, point dose, visual dose distribution

In this study, this data was used to analyze and compare the dose calculated on the planning CT and on the CBCT images of the 10 partial brain treatments. Due to the anatomical similarities during brain treatments, if the dose calculation is correct and CT-to-ED tables are sufficiently accurate, there is no expected difference in dose calculated on the planned CT and on the CBCT.

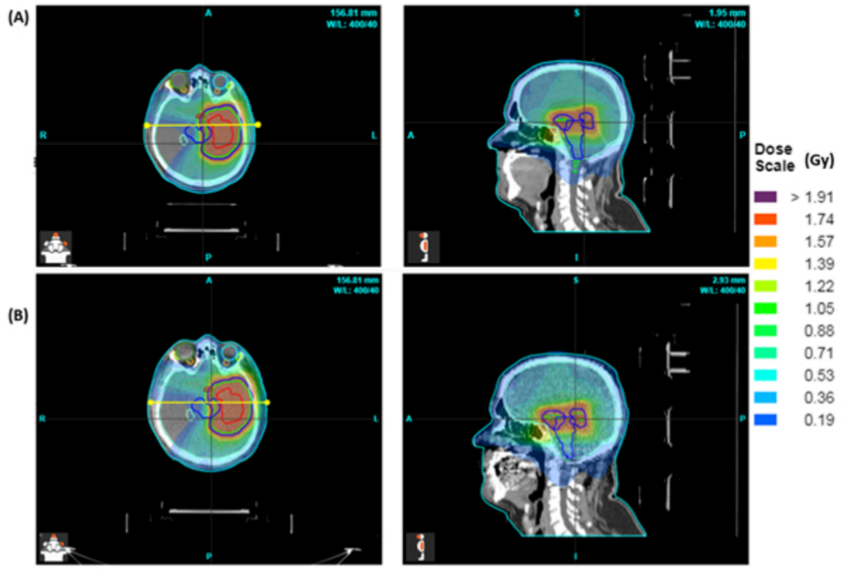
The overall 3D gamma (using a 3%/3mm criteria) showed good agreement (1.04% difference) between the dose calculation on CBCT and planning CT. Additionally, max point doses for the brainstem (2.4 cGy avg difference), chiasm (0.9 cGy avg difference), and left and right globes (0.3 cGy and 0.6 cGy, avg differences respectively) also showed good agreement between the two datasets.

Faux treatment delivered on RANDO phantom



Head and neck portion of RANDO phantom was used to demonstrate the full workflow of using CBCT-based dose verification.

Dose calculated on CT and CT-CBCT merged anatomy



Good agreement of isodose distributions was found between planning CT and CBCT images.

Statistical results from the partial brain treatment patients

	Avg % Difference	Avg cGy Difference	p-value
Brainstem	1.27	2.36	0.98
Globe_L	0.17	0.27	0.9
Globe_R	6.46	0.55	0.99
Chiasm	0.48	0.91	0.99
3D Gamma	**1.04**	---	0.6

Max dose differences between several OARs and overall 3D gamma analysis shows good agreement between the planning CT and CBCT-based doses.

CONCLUSIONS

A CBCT-based clinical dose verification workflow allows for evaluation of dose coverage and OAR sparing via quantitative post-delivery analysis. This makes it possible to use quantitative measures to recommend a replan, if it is deemed necessary

Practically no additional clinical burden to utilizing this method routinely
- If PerFraction™ is utilized for IMRT QA, images and log files are routinely acquired, and CT-CBCT fusion and dose calculation can be automated

This study demonstrates that it is clinically feasible to use CBCT images in a clinical dose verification workflow.

Ongoing study
- Utilizing various CBCT-to-ED calibration curves for improved dose calculation, in particular the low-density regions
- Comparison of dose distributions in more complex treatment sites such head and neck

ACKNOWLEDGEMENTS

The authors thank all the radiation therapists and dosimetrists at Cleveland Clinic for their continued excellence in radiation therapy treatment planning and delivery.

REFERENCES

Adamson J, Carroll J, Trager M, et al. Delivered Dose Distribution Visualized Directly With Onboard kV-CBCT: Proof of Principle. *Int J Radiat Oncol Biol Phys.* 2019;103(5):1271-1279. doi:10.1016/j.ijrobp.2018.12.023

Chen S, Le Q, Mutaf Y, et al. Feasibility of CBCT-based dose with a patient-specific stepwise HU-to-density curve to determine time of replanning. *J Appl Clin Med Phys.* 2017;18(5):64-69. doi:10.1002/acm2.12127

Qin A, Gersten D, Liang J, et al. A clinical 3D/4D CBCT-based treatment dose monitoring system. *J Appl Clin Med Phys.* 2018;19(6):166-176. doi:10.1002/acm2.1247

CONTACT INFORMATION

Gleb Kuzmin
dr.gleb.kuzmin@gmail.com

Peng Qi
qip@ccf.org