Geometric Rectification of 6DoF CBCTs: Streamlining Dose Calculation in Commercial TPS

Ren-Dih Sheu, Kiran Pant, Jiahan Zhang, and Yang Lei
Icahn School of Medicine at Mount Sinai, New York, NY

2026 JULY 19–22 VANCOUVER, BC
JOINT AAPM | COMP MEETING

ABSTRACT

Commercial TPS platforms cannot directly calculate dose on CBCT images acquired with 6DoF couch corrections, limiting dosimetric evaluation of verification scans. This study introduces an offline workflow that rectifies tilted CBCT geometries and generates pseudo-matched CBCT datasets for adaptive dose evaluation.

The workflow, developed in Python with SimpleITK, uses inverse transformation matrices from DICOM headers to restore CBCT images to standard axial geometry. A web-based interface integrated with MOSAIQ through ODBC connections enables streamlined image selection and automated processing without manual export steps. Synthetic "what-if" CBCT datasets can also be generated using planned couch shifts.

Validation with phantom and clinical datasets demonstrated accurate geometric correction and alignment within MOSAIQ and Eclipse. The workflow achieved sub-voxel spatial accuracy, with mean 3D deviations below 0.5 mm from phantom ground truth, while maintaining processing times under 30 seconds per case.

This automated solution overcomes TPS limitations related to couch-rotated CBCT images and provides an efficient pathway for offline adaptive radiotherapy and dose re-evaluation. The integration of automated rectification and database connectivity significantly reduces manual intervention and improves clinical usability.

CONTACT

Ren-Dih Sheu
Mount Sinai Health System
1184 5th Ave, New York, NY 10029
ren-dih.sheu@mountsinai.org
212-241-9074

INTRODUCTION

- **6DoF couch corrections** improve patient setup accuracy but create CBCT geometries that are incompatible with dose calculation in commercial TPS such as Eclipse.
- This limitation prevents direct dosimetric evaluation of daily verification CBCTs and third-party software is required.
- We developed an automated workflow to **rectify tilted CBCTs** and generate TPS-compatible datasets for **offline adaptive radiotherapy (ART)** and dose re-evaluation.

METHODS AND MATERIALS

- Developed an automated workflow using **Python** and **SimpleITK**.
- Applied **inverse transformation matrices** from DICOM headers to correct 6DoF CBCT geometries.
- Created a **web-based interface** with **ODBC connectivity to MOSAIQ** for direct CBCT retrieval and processing.
- Enabled generation of **pseudo-matched CBCTs** by applying planned shifts from the Spatial Registration Object (SRO).
- Validated using both **phantom** and **clinical** datasets.

Key Innovation

- ❑ Direct bridge between **MOSAIQ** and **Eclipse**
- ❑ No manual file export or third-party software
- ❑ Fully automated workflow

RESULTS

- Geometric accuracy verified in both MOSAIQ and Eclipse.
- Mean 3D positional deviation: < 0.5 mm (sub-voxel accuracy).
- Successfully generated rectified and pseudo-matched CBCT datasets for TPS dose calculation.
- Total processing time: < 30 seconds per dataset.

Key Findings

- ❑ Sub-voxel geometric accuracy
- ❑ Successful dose calculation on previously incompatible 6DoF CBCTs
- ❑ One-click processing workflow

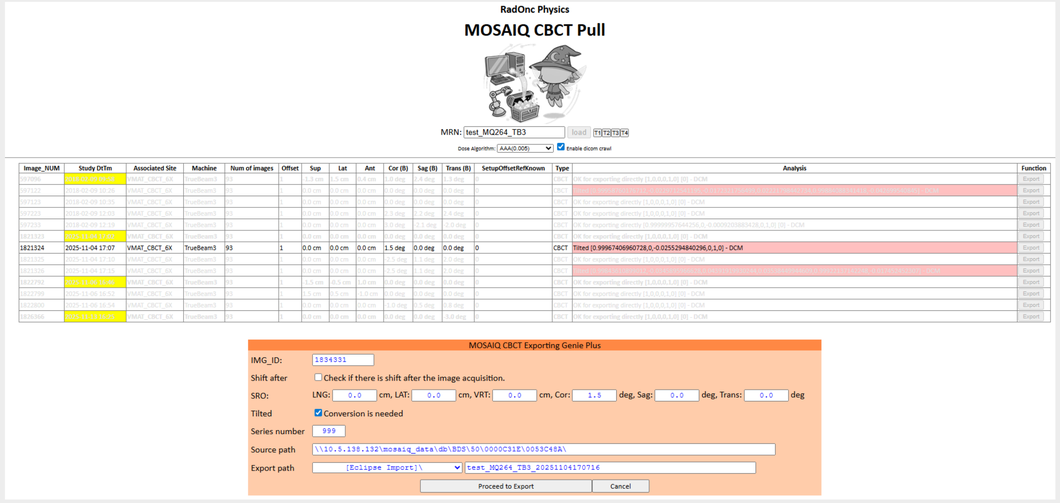

Fig.1. Web-based application to retrieve CBCT from MOSAIQ via ODBC.

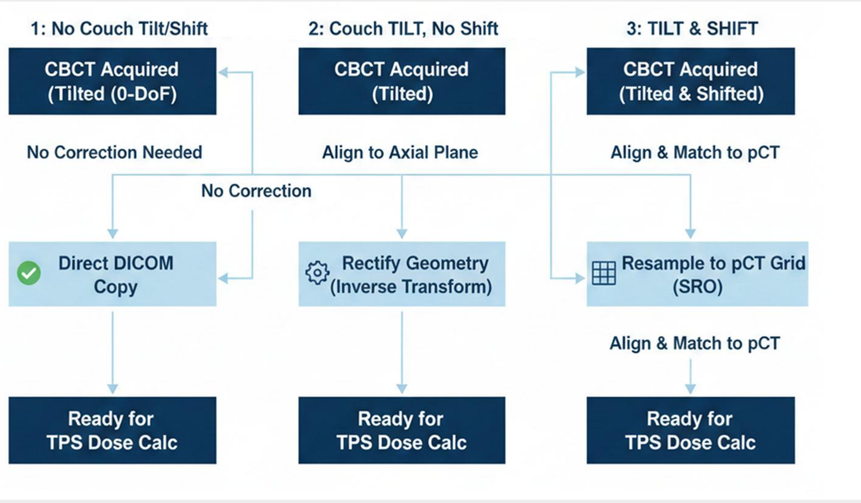

Fig.2. Streamline: 6DoF CBCT conversion workflow

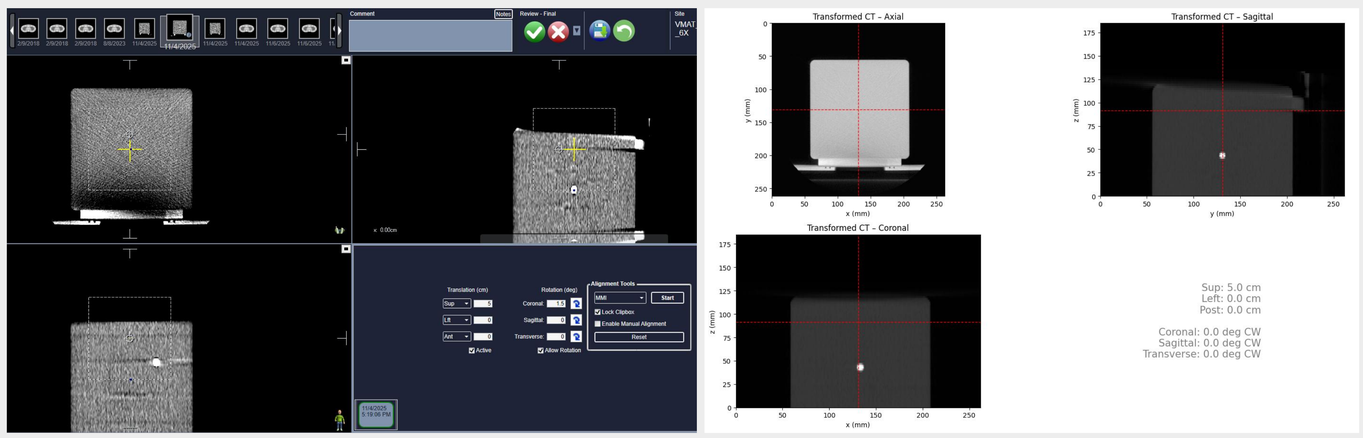

Fig. 4 Validation of pseudo-matched image generation (5 cm superior shift with a tilted CBCT: 1.5-degree rotation)

Fig. 5 Dose calculation in Eclipse using pseudo-matched and rectified CBCT datasets.

DISCUSSION

- Overcomes the commercial TPS "6DoF blockade" for CBCT dose calculation.
- Converts daily verification CBCTs from positioning tools into dosimetric evaluation datasets.
- Supports offline ART, dose tracking, and treatment assessment using existing clinical infrastructure.
- Streamlined workflow improves efficiency and reduces manual intervention.

CONCLUSIONS

- Developed a fast, automated solution to rectify 6DoF CBCTs and enable TPS-based dose calculation.
- Achieved < 0.5 mm geometric uncertainty and < 30-second processing time.
- Provides a practical pathway for offline adaptive radiotherapy, daily dose monitoring, and treatment plan re-evaluation within existing clinical workflows.

REFERENCE

- R. Beare, B. C. Lowekamp, Z. Yaniv, "Image Segmentation, Registration and Characterization in R with SimpleITK", J Stat Softw, 86(8), doi: 10.18637/jss.v086.i08, 2018.
- Z. Yaniv, B. C. Lowekamp, H. J. Johnson, R. Beare, "SimpleITK Image-Analysis Notebooks: a Collaborative Environment for Education and Reproducible Research", J Digit Imaging., doi: 10.1007/s10278-017-0037-8, 31(3): 290-303, 2018.
- B. C. Lowekamp, D. T. Chen, L. Ibáñez, D. Blezek, "The Design of SimpleITK", Front. Neuroinform., 7:45. doi: 10.3389/fninf.2013.00045, 2013.