A method for measuring the setup accuracy of an IGRT system for single-isocentre, multiple target SRS deliveries

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PURPOSE / OBJECTIVE

- The single isocentre, multiple target technique is frequently used in the stereotactic radiosurgery (SRS) treatment of multiple brain metastases.
- While there are well developed methods for quantifying the accuracy of isocentric SRS treatments, there is no standard method that can be used to measure the setup accuracy of multi-focal single isocentre treatments.
- In this work, we propose a method that uses an electronic portal imaging device (EPID) for quantifying the targeting accuracy of an IGRT system for a single isocentre multiple target SRS treatment technique.

MATERIALS / METHODS

1. Treatment planning and phantom setup

Figure 1. Left: Shows the test phantom setup on a Varian STX TrueBeam linac that is equipped with a 6DoF couch. **Right:** An anterior digitally reconstructed radiograph (DRR) showing a total of 8 targets. The treatment field has 7 treatment ports exposing all but target 3. Isocentre location coincided with target 4.

- A phantom study was designed to evaluate the setup accuracy of an IGRT system for single isocentre multiple target SRS deliveries.
- The first part of the process involves making an immobilization mask for an anthropomorphic head phantom which has radio-opaque markers (BBs) located at various positions within the phantom.
- A helical CT dataset was acquired using a 0.625 mm slice thickness / spacing and a treatment plan was generated using Varian's Eclipse software.
- The treatment plan consisted of several treatment fields containing multiple rectangular openings defined by the TrueBeam High Definition MLC (HDMLC), Isocentre was selected at the center of target BB 4. Table 1 shows the gantry and couch combinations used in the treatment plan.
- The phantom was setup on the treatment unit using CBCT and the six degree of freedom couch (6DoF). Images of the treatment fields were acquired with the EPID positioned at 80 cm from isocentre thereby achieving the largest magnification possible.

Table (°)	0	90	270
Gantry(°)	0, 90, 180, 270	0, 180	0, 180

Table 1. Gantry and couch combinations used in this study.

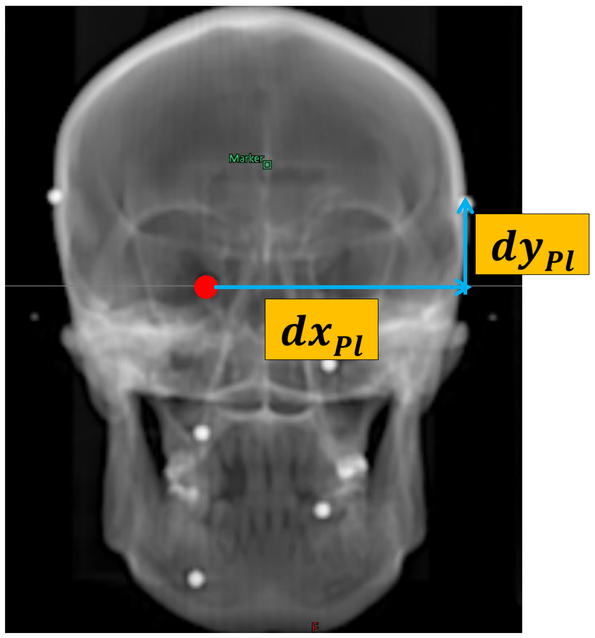
MATERIALS / METHODS

2. Data analysis

The localization accuracy for each target was determined as follows:

- The crossline and inline distances between the isocentre and the target location (dx_{Pl} and dy_{Pl}) were calculated for each target from the treatment plans.
- The corresponding distances were measured on the portal images (dx_M and dy_M).
- The localization accuracy Δ was determined by comparing the distance between the target center and the isocentre measured on the portal image $(\vec{d}_m)$ with the corresponding distance calculated from the treatment plan $(\vec{d}_{Pl})$.

$$\Delta x = dx_{Pl} - dx_M \qquad and \qquad \Delta y = dy_{Pl} - dy_M$$



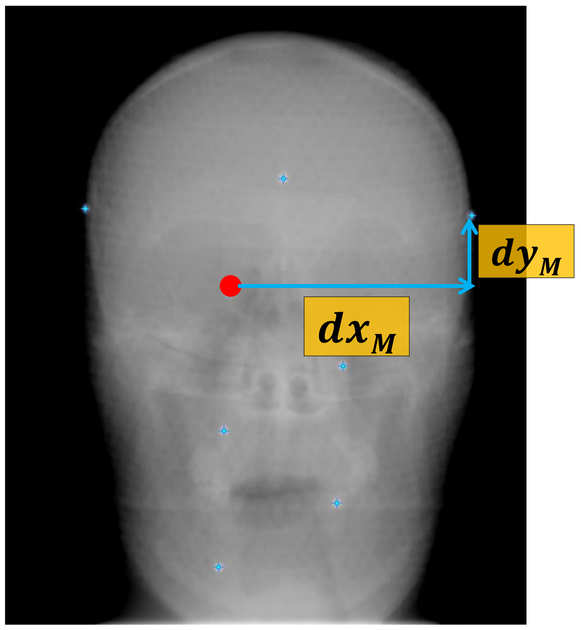


Figure 2. Top: Anterior open field DRR. **Bottom:** Anterior open field EPID image. The inplane / crossplane distances are measured on both images from isocentre (red dot) to target 2.

RESULTS

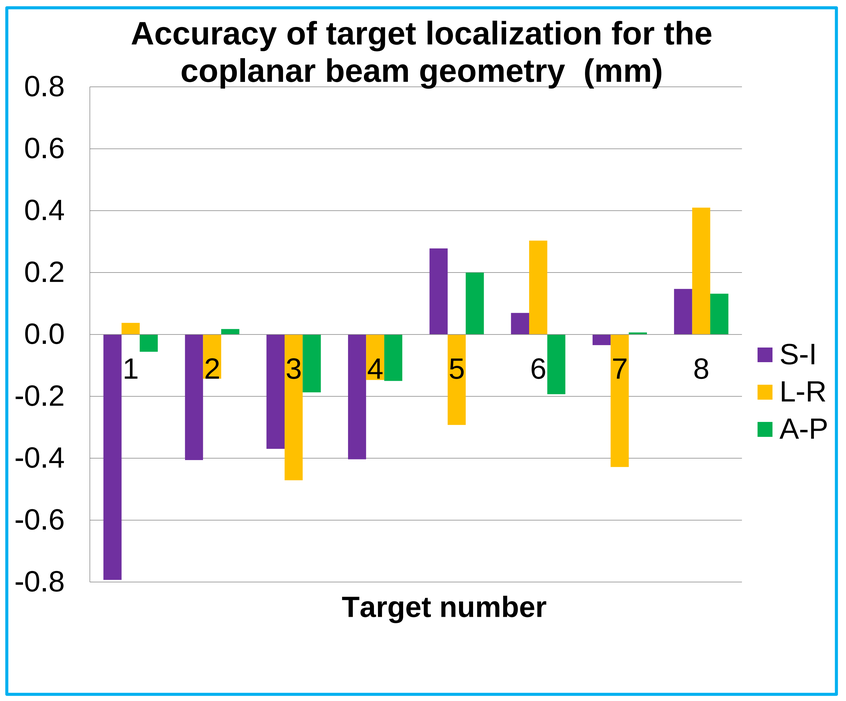


Figure 3. Target localization accuracy (Δx and Δy) measured in the "superior / inferior", "left / right" and "anterior / posterior" directions. Averages were taken over the four cardinal gantry angles.

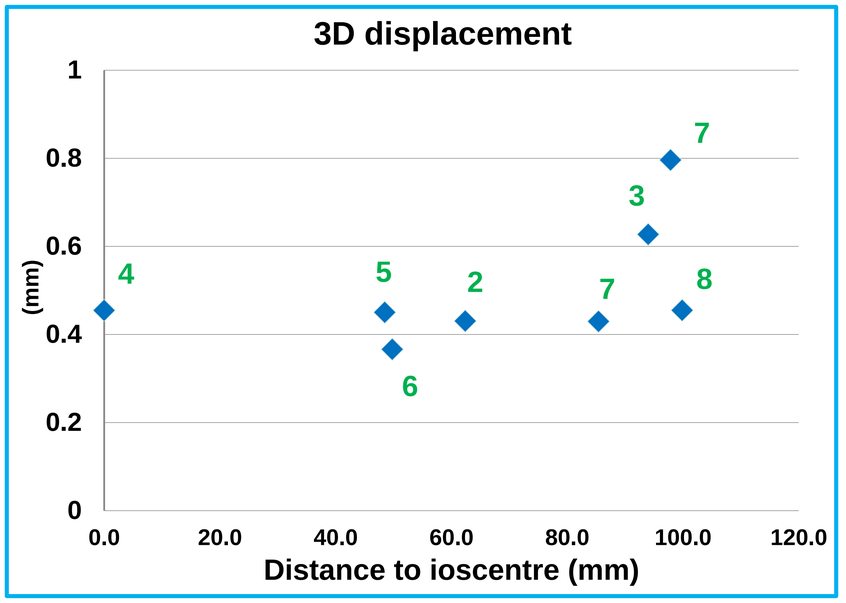


Figure 4. 3D displacement as a function of distance from the isocentre for the eight targets. The numbers on the plot are the target numbers as labelled on Figure 1.

CONCLUSION

This work indicates that a positional accuracy of < 1.0 mm can be achieved for cranial off-axis targets when corrections are made using CBCT imaging in combination with the 6DoF couch.

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