**Leveraging a Multi-Institutional Consortium to Understand Dose Accuracy in the Near-Surface Region for Whole Breast Irradiation**

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**Purpose:** To assess accuracy of dose calculations in the near-surface region for different treatment planning systems (TPSs), plan complexities, and energies to improve clinical decisions for patients receiving whole breast irradiation (WBI). This work is part of a multi-institutional effort investigating the correlation between mean dose calculated in the near-surface region and acute skin toxicities considering different WBI treatment techniques.

**Methods:** A portable custom breast phantom was designed for measurements at eight institutions. Clinically-relevant treatment plans (open, field-in-field (FiF), FiF mixed-energy, and IMRT) were created in four TPSs on a patient dataset (50Gy/25fx) and peer reviewed by participants. After transfer to the phantom dataset, plans were re-calculated with fixed monitor units. For each irradiation, which included linear accelerators from different vendors, the phantom was aligned with predetermined moves or CBCT. Dose was measured with radiochromic film (1.5cmx13.0cm) placed at two depths (0.5 and 1.0cm) and three locations per depth within the phantom. Film was scanned (> 24h post-irradiation) and analyzed using FilmQA Pro. Dose differences were evaluated relative to the calculation.

**Results:** Measured and calculated doses agreed well for all TPSs, complexities, and beam energies with 86.7%, 77.8%, 91.9%, and 80.6% of measurements within ±5% agreement for open field, FiF, FiF mixed-energy, and IMRT, respectively. Based on a Gaussian fit of the difference distribution, the mean percent difference was -0.2±2.9%, with 95% of measurements within 6% agreement. Furthermore, Pearson correlation scores (# of measurements) of 0.8(60), 0.9(54), 0.7(36), and 0.8(72) showed good agreement for open fields, FiF, FiF mixed-energy, and IMRT, respectively.

**Conclusion:** To the best of our knowledge, these results demonstrate that dose calculations from clinically relevant WBI plans for various complexities and beam energies are accurate in

the near-surface region. This lays the foundation for future work to investigate the correlation between near-surface dose and patient skin toxicities.

**Innovation/Impact**: This study addresses the accuracy of TPSs and delivery systems in a multi-institutional consortium in the near-surface region. Also, it sets a foundation for future work to evaluate correlations between skin toxicities and dose.

**Key Results**: When reviewed in aggregate, our results show that accurate near surface doses can be calculated with various TPSs, treatment complexities, and beam energies and for different delivery systems.

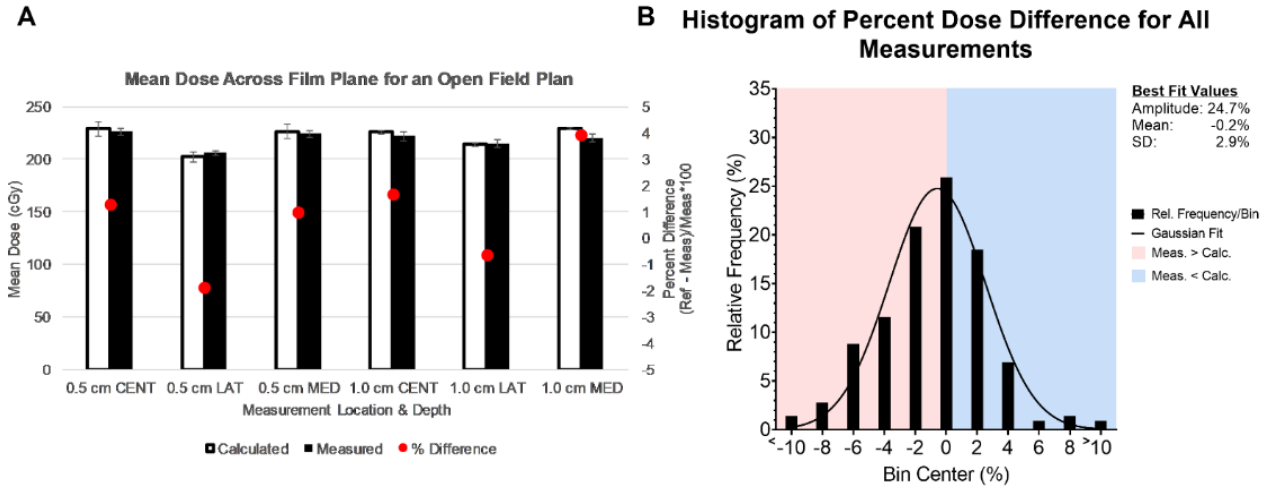


**Figure 1:** (A) Example dose comparison between the mean of the measured and calculated dose for a single open field plan, with <5% agreement for all measurement depths and laterality. (B) A Gaussian fit of a histogram of the percent dose difference for all measurements (TPSs and delivery systems). Based on the Gaussian fit, the mean percent difference is -0.2 ± 2.9%, thus 95% of all the measurements fall within ±6% of agreement.

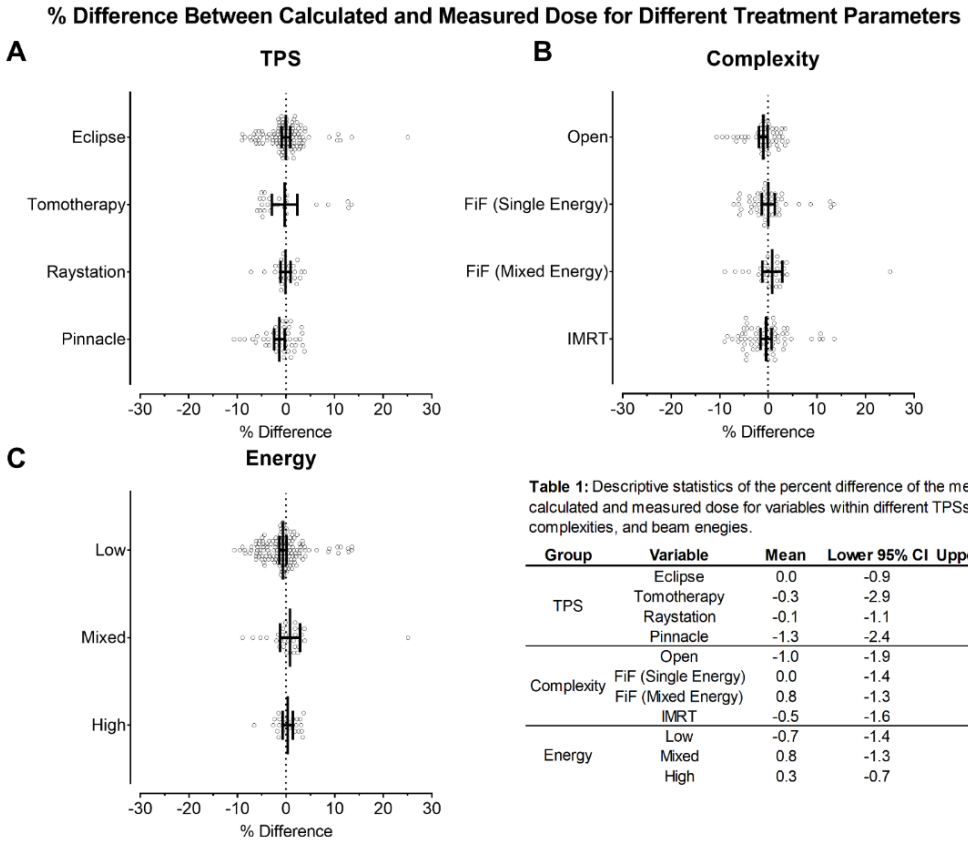


**Table 1:** Descriptive statistics of the percent difference of the mean calculated and measured dose for variables within different TPSs, plan complexities, and beam enegies.

| Group | Variable | Mean | Lower 95% CI | Upper 95% CI |
|---|---|---|---|---|
| TPS | Eclipse | 0.0 | -0.9 | 0.9 |
| | Tomotherapy | -0.3 | -2.9 | 2.4 |
| | Raystation | -0.1 | -1.1 | 1.0 |
| | Pinnacle | -1.3 | -2.4 | -0.3 |
| Complexity | Open | -1.0 | -1.9 | -0.1 |
| | FiF (Single Energy) | 0.0 | -1.4 | 1.3 |
| | FiF (Mixed Energy) | 0.8 | -1.3 | 2.9 |
| | IMRT | -0.5 | -1.6 | 0.7 |
| Energy | Low | -0.7 | -1.4 | 0.1 |
| | Mixed | 0.8 | -1.3 | 2.9 |
| | High | 0.3 | -0.7 | 1.4 |

**Figure 2:** The individual percent difference between the mean of the measured and calculated dose for different parameters. None of the distributions were statistically different from zero, demonstrating good agreement between all experimental conditions and accurate near surface dose calculations. There were a few outliers observed, which are likely setup errors due to the lack of image guidance to support the measurement setup.

**Table 1:** Statistical evaluation by TPS, complexity, and beam energy.

This analysis will support subsequent evaluation of planned dose in the near surface regions. The potential correlation to patient toxicity via patient and physician reported outcomes for whole breast radiotherapy patients treated with different delivery techniques throughout a statewide consortium will be evaluated. It may also inform future investigations evaluating skin toxicity in clinical trial settings.