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# Comparing Patient Setup Techniques utilizing Optical Surface Guidance and Conventional Tattoo/Laser Alignment from Cherenkov Image Consistency Metrics


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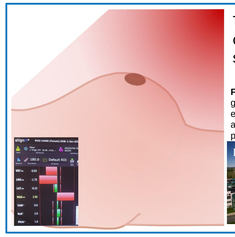
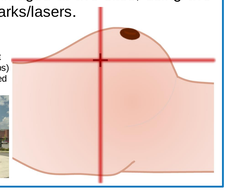
## PURPOSE / OBJECTIVES



The purpose of this study is to compare metrics used to describe treatment consistency of breast radiation therapy fractions imaged at two sites, using two setup techniques: SGRT and conventional skin marks/lasers.

**Figure 1** at Dartmouth-Hitchcock Medical Center in Lebanon, NH, optical surface guidance (AlignRT, VisionRT – London, UK) was used to align patients for treatment each day. At Cheshire Medical Center in Keene, NH, conventional skin marks (tattoos) and lasers indicating room isocenter were used for alignment). Fractions were imaged passively using iCMOS Cherenkov Cameras (DoseOptics, Lebanon, NH).





## BACKGROUND

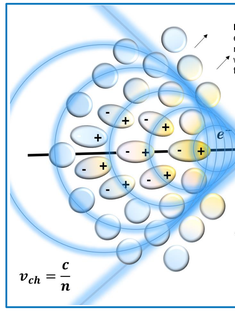
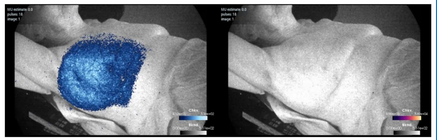



**Figure 2**: in the wake of the electron, electronic disturbances requilibrate to produce optical light which constructively interfere, forming a coherent wavefront.

**Figure 3:** The Cherenkov light is imaged frame by frame (left) and the cumulative image (right) is used for analysis.

In the context of radiotherapy, Cherenkov light is emitted in dielectric (polarizable) media (e.g. water in the patient), when an incoming, MV x-ray photon ionizes an electron, leaving it with enough energy to travel faster than the phase velocity of light in the medium (Figure 2). Imaging light at these low intensities involves time-gating the exposure around the Cherenkov emission using the linac pulses (Fig. 3).



## METHODS

In this IRB approved study, patients' daily treatments (Table 2) were imaged and the same intensity threshold applied to each fraction. Two constancy metrics 1) DICE similarity index (% similarity) and mean distance to conformity (MDC, distance between like points on comparable masks) were computed, averaged and compared for each patient. (Shown in Figures 6 and 7).


**Figure 4:** A given patient's imaged fractions are shown to the left, with binary image masks shown adjacent. Two comparisons are made: 1) subsequent fractions as compared to the first fraction, and 2) all fractions as compared to the treatment plan.

# Main Findings

The hypothesis that there exists a significant difference between the Cherenkov image-evaluated consistency between the optical surface guidance setup technique and the conventional skin marks/lasers setup technique was nullified after analysis using a two-tailed t-test of unequal variance.

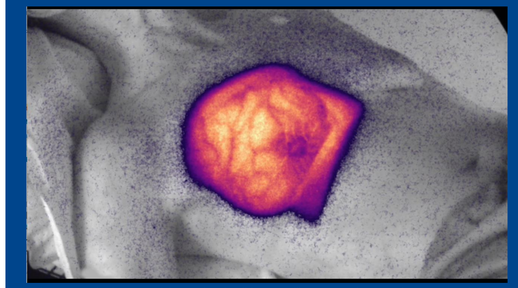
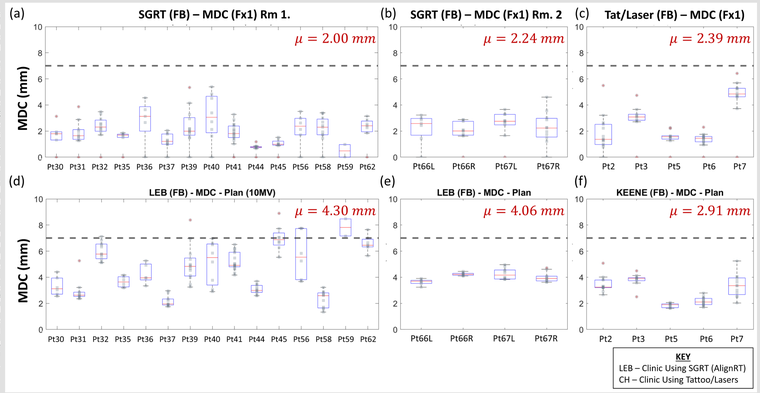


**Figure 5:** As is shown, each image thumbnail from a ceiling-mounted camera demonstrates that substantial variability can be readily observed from fraction to fraction, risking dose to contralateral anatomy. The fact that Cherenkov imaging is very sensitive to change makes it a good modality for monitoring subtle differences in treatment.

**Table 1:** Metrics are listed for the two-tail t-test of unequal variance. The null hypothesis could not be rejected, and p-values illustrate this clearly. It can be observed, however, that assessing the mean distance to conformity may serve as a less insignificant metric for analysis, and should likely be re-evaluated upon of more patient data at both sites.

| Statistic | DICE | MDC |
|---|---|---|
| Null Hypothesis Rejected | NO | NO |
| P-value (p) | 0.43 | 0.09 |
| Confidence Interval | [-0.57 0.25] | [-0.68 0.05] |
| T-statistic | -0.79 | -1.69 |
| Degrees of Freedom | 159.6 | 139.0 |
| Standard Deviations (Unpooled) | DHMC Lebanon: 1.39<br>DHMC Cheshire: 1.52 | DHMC Lebanon: 1.11<br>DHMC Cheshire: 1.44 |

**Figure 6:** Patient data for the mean distance to conformity, organized by institution, FB/DIBH, and whether that those fractions are being compared to the intensity mask extracted from the first day of treatment (Fx1), or the mask rendered from the surface dose in the treatment plan (Plan). The means are listed in red. L/R indicating Right or Left side imaged. Differences as compared to plan are usually higher in magnitude, indicating evidence of some systematic offsets. Thus, comparing to the first day of treatment is assumed to be a more reliable means of assessment at this time. This data was used for statistical analysis.




## RESULTS

**Figure 7**

Figure 7 follows the format of Figure 2, and organizes patient data for DICE criterion by institution, FB/DIBH, and whether that those fractions are being compared to the intensity mask extracted from the first day of treatment, or the mask rendered from the surface dose in the treatment plan.

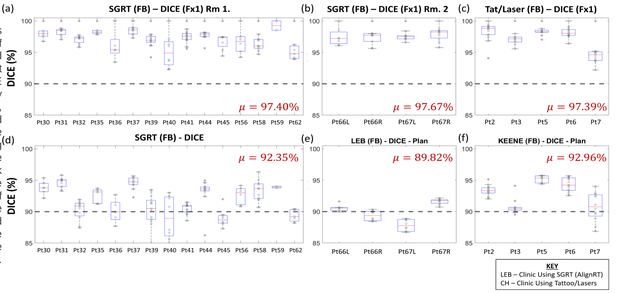



**Table 2**

Table 2 provides a breakdown of the number of patients and fractions imaged at each site, organized by free-breathing (FB) or deep-inhalation breath hold (DIBH).

| | DHMC – LEBANON (SGRT) | | DHMC – KEENE (Tattoo/Lasers) | |
|---|---|---|---|---|
| Free – Breathing | $n$ = 15 | $f_x$= 134 | $n$ = 5 | $f_x$= 54 |
| Deep Inhalation Breath Hold | $n$ = 0 | $f_x$ = 0 | $n$ = 3 | $f_x$= 26 |

## SUMMARY/CONCLUSIONS

This study presents the first comparison of quantitative consistency between two widely used setup techniques using remote imaging of Cherenkov light, incorporating the largest cohort of patient data available.

While no significant differences separated conventional laser alignment to SGRT, MDC was shown to be less insignificant, indicating that this metric may be more sensitive to change, and that more patient data could potentially frame different conclusions in future work.

## FUNDING / DISCLOSURES / CONTACT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