Surface-Guided Radiation Therapy (SGRT) with 3D printed bolus material

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Introduction

Bolus is often used in radiation therapy to compensate for missing tissue and provide build-up to the skin surface. Our department previously used super flab, however it has conformity issues and often results in an air gap with patients' skin resulting in dosimetric uncertainties. To address such issues, 3D printed boluses are commonly used in the clinic (Robar, Moran et al. 2018) . Whilst we have printed over 1900, 3D boluses since 2018, we noticed material colour and texture are important for accurate surface reconstruction and monitoring by optical surface imaging systems. This study aims to compare the effect of 3D printed bolus colour material with AlignRT system (AlignRT® Advance V6.3 with Gen 5 cameras).

Method and Materials

Using established 3D printed workflow as shown in Figure 1, we printed three boluses using Esun Natural PLA, Esun PLA+ (Green) and Matte-PLA (Fair skin) referred 'Spidermaker' materials as shown in Figure 2. Surface within bolus on a female Mannequin was monitored with AlignRT throughout a typical 360 degree arc treatment delivery from a linear accelerator. The effect of each bolus material's colour were compared by keeping the constant colour tone setting within the AlignRT® Advance application.

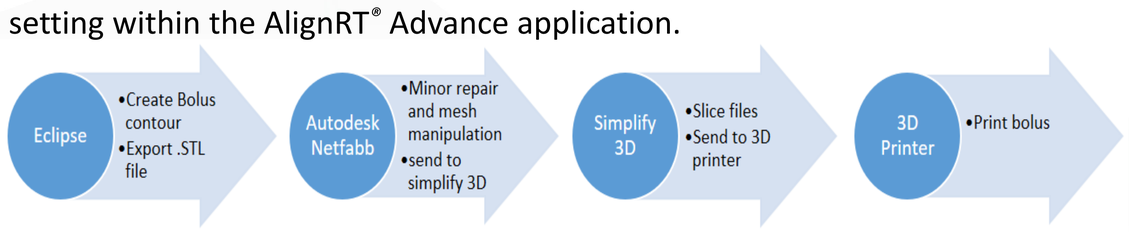

Figure 1: Schematic of typical workflow of bolus printing

Results and Discussion

Poor surface reconstruction and detection were noticed visually for Natural PLA and PLA+ (Green) compared to Spidermaker bolus material as shown in Figure 2. Dosimetric differences were found to be negligible (refer Table 1). Treatment time ranges from 60.0 s – 116.3 s. We could not deliver the entire treatment for PLA+ (Green) material initially due to the systems inability to detect enough surfaces around the region of interest (ROI). This required an adjustment to the skin tone setting within the AlignRT application to complete treatment. Figure 3 shows the example of the distribution of 3D vector sum (MAG) of translation real time deltas (RTD) for each bolus in this study. Noisy RTDs resulted in ~100% increase in time for PLA+ (Green) compared to Spidermaker (Fair skin) bolus.

*Table 1: shows the delivery time and ion chamber readings for each bolus scenario presented in this study. *For PLA+ (Green) colour bolus, skin tone setting was changed from medium to dark to complete treatment delivery.*

	Natural PLA	PLA+ (Green)*	Spidermaker
Delivery time(s)	63.3	116.4*	60.0
IC reading(nC)	21.7	21.7*	21.7

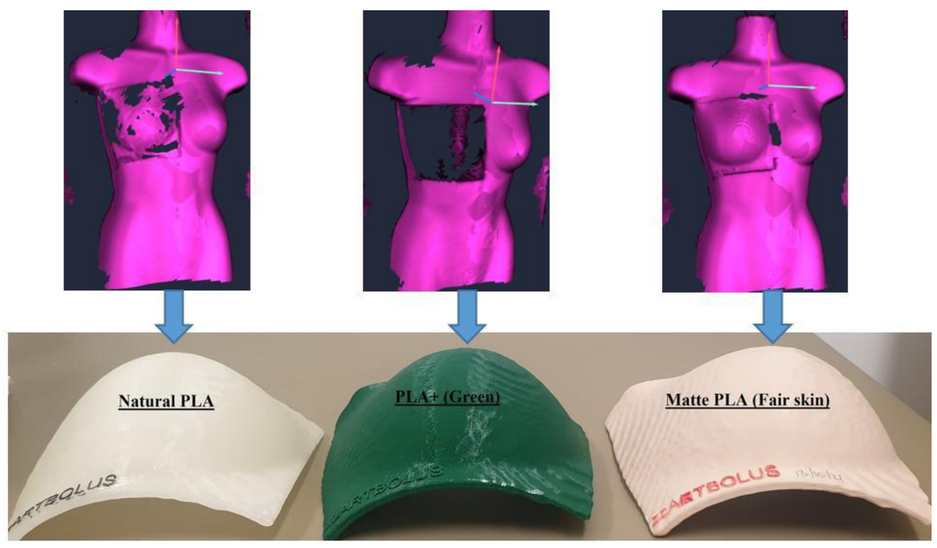

Figure 2: Illustration of reference captured for various coloured PLA material with AlignRT system. The dark region indicate the system's inability to reconstruct the surface due to lack of signal. Pink region indicate the system ability to reconstruct the surfaces.

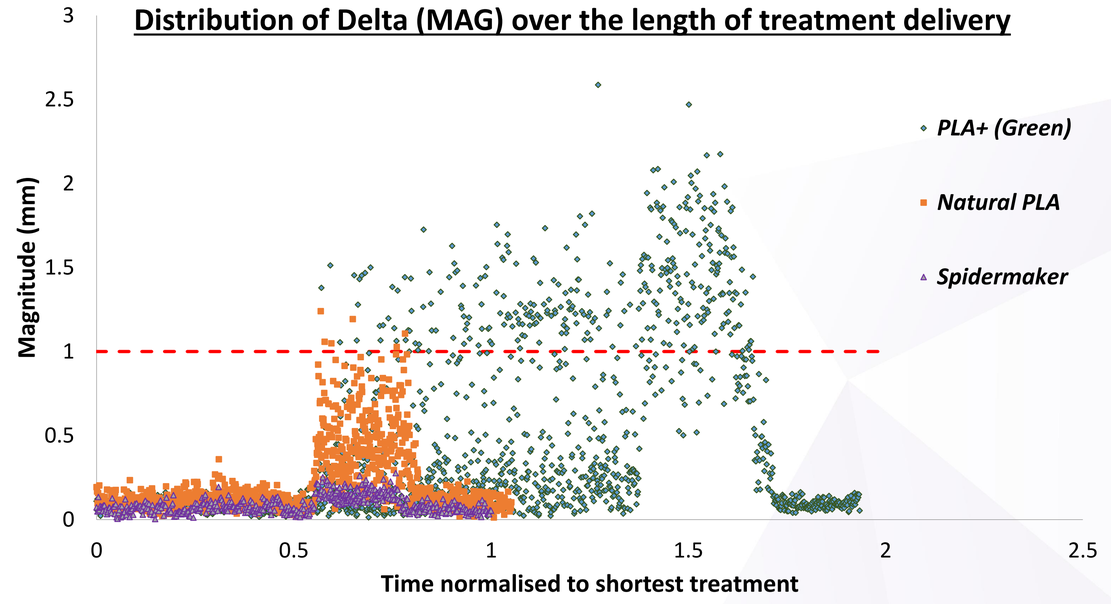

Figure 3: shows the distribution of Delta magnitude of translational RTDs for each bolus colour material normalised to the shortest time of treatment delivery scenario.

Limitations and Considerations

- IC readings unaffected from material density due to measurement perform away from bolus materials in this study however need to be considered
- Inferior surface overlap results beam hold beside RTDs outside tolerance
- Identical ROI drawn on top of bolus may have minor user variations
- Minor uncertainties in reproducible positioning of bolus on the phantom

Conclusion

We investigated suitability of different 3D-printed bolus materials with AlignRT, which have various impacts in clinical scenarios. 3D-print material with colour similar to realistic skin are found to provide accurate monitoring without giving noisy RTDs which increases beam interruptions and in some instances inability to continue treatments.

References

Robar, J. L., et al. (2018). "Intrapatient study comparing 3D printed bolus versus standard vinyl gel sheet bolus for postmastectomy chest wall radiation therapy." Practical radiation oncology **8**(4): 221-229.