Using the CIRS dynamic phantom to compare AlignRT® with the Varian RPM Motion Management System

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Background

During commissioning of a new AlignRT® Advance SGRT system at Hammersmith Hospital, the dynamic accuracy of the system was evaluated and compared against the current Varian RPM motion management system used for DIBH treatment. The effects of skin tone and room lighting on the system performance were also assessed. To facilitate these investigations, a bespoke solution was devised using the CIRS dynamic respiratory phantom with an in-house manufactured XENA attachment. The commissioning tests were developed using the ESTRO-ACROP guidelines and AAPM task group report 302.

Skin Tone and Room Light Impact

Methods & Materials

The XENA phantom was manufactured by vacuum-forming a plaster cast of a thorax phantom with 2 different-sized breast moulds, painted with 2 different tones to represent lighter-skinned and darker-skinned patients. A series of surface captures were acquired with the phantom positioned as shown in figure 1, with multiple combinations of room lighting and skin tone settings applied. The captures were assessed qualitatively (visual assessment) with respect to capture quality (accuracy of surface captured) and the size/number of gaps in the surface acquired. Optimal parameters for either skin tone were determined based on visual assessment. ROIs of similar size were placed on either region and couch shifts of 2cm were applied in each direction. The resulting Real-time Delta values were recorded to determine the accuracy of shift detection under optimal conditions.

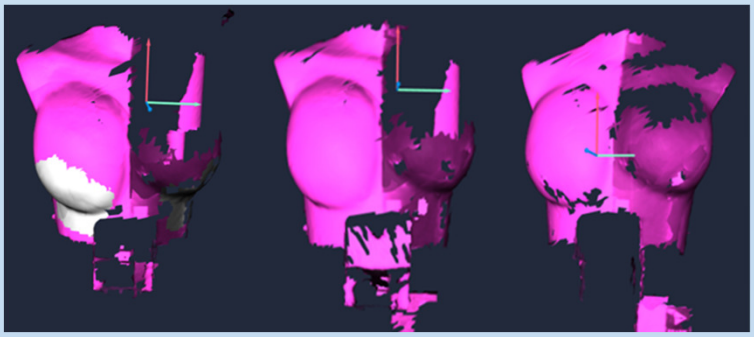


Figure 2: (left) Surface capture – no lights on, mid skin-tone setting; (middle) Surface capture – all lights on, mid skin-tone setting; (right) Surface capture – all lights on, darkest skin-tone setting

Results

Both room lighting and skin tone settings had a noticeable effect on the quality of the surface captures for the darker skin tone region. Changing the skin tone setting to "dark" resulted in a more significant improvement in surface quality than improving lighting conditions, mainly with respect to reducing gaps in the dark skin-tone surface. This is demonstrated in figure 2 above.

The average errors in the shifts detected were 0.2mm when monitoring the ROI in the light skin-tone region, and 0.6mm when monitoring the ROI dark skin-tone region. Additionally, all RTD values were in tolerance for the light skin-tone ROIs, whereas 58% of RTDs measured by the dark skin-tone ROI were out of tolerance. Shifts were repeated for the dark skin-tone using a larger ROI and a larger pitch to better mimic a clinical setup, as well to lessen shadowing in the superior region of the phantom. The average error in the repeated shifts reduced to 0.2mm (equivalent to light skin tone) and all RTD values were within tolerance. This indicates that an equivalent level of accuracy can be obtained for darker skin tone by ensuring a sufficiently large ROI is used, and by optimising skin tone and lighting settings for different patient groups.

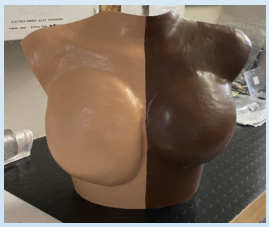
Comparing Dynamic Accuracy to Varian RPM

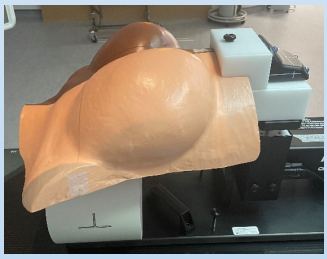
Methods & Materials

The dynamic accuracy was measured by using the Xena and the CIRS dynamic respiratory phantom. The surface was attached to the gating platform (se figure 2). The phantom was programmed to move with a set amplitude and frequency, and the motion tracked by AlignRT® and the Varian RPM system. The real time deltas were exported and compared to the programmed trace and the Varian recorded trace.

Results

Our clinical system was able to simultaneously track the movement using both AlignRT and the Varian RPM system at the same time. In this case the frame rate of the RPM system was half that of AlignRT (influenced by the large ROI used to monitor, however still less than 40ms between readings). Figure 3 shows a plot of the deltas extracted from both systems, for a programmed breathing cycles of 1cm amplitude and 4s cycle length. Whilst there is a systematic offset in the AlignRT delta(<1mm Negative) due to being below the system tolerance, there were minimal differences in the magnitude of the breathing amplitudes and cycle lengths when comparing to the set positions.





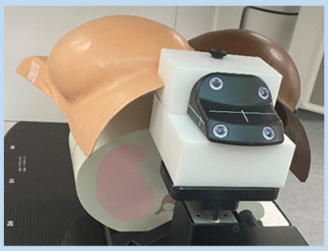


Figure 1: XENA phantom attatched to the CIRS dynamic respiratory phantom with the Varian RPM block

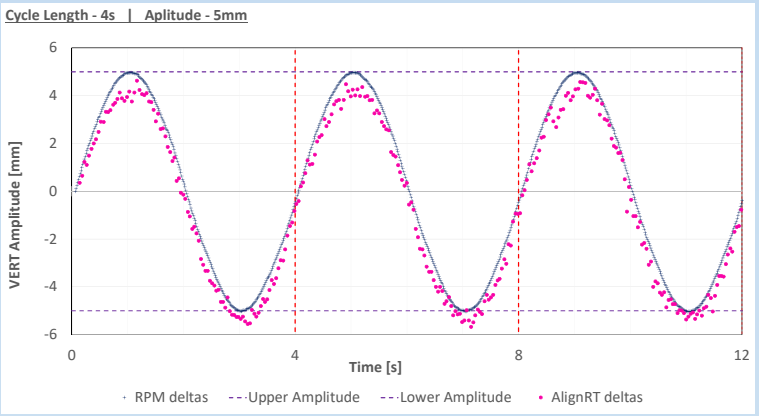


Figure 3: Real-time Delta data extracted from AlignRT and Varian RPM and plotted in Excel. Red Dash Lines = Expected Cycles, Purple Dashed Lines = Expected Amplitudes

Conclusions & Future Works

There were minimal differences in amplitude and cycle length when comparing the CIRS set amplitude and frequency to AlignRT® or Varian RPM systems, with near instantaneous beam interrupt. Differences in room lighting and skin tone settings had a detectable effect on surface capture quality and shift detection, and the importance of these parameters as well as ROI size and patient position was quantified for darker skin tones. The XENA facilitated the optimisation of skin tone and lighting setting for patients with darker skin tone, which will feed into our local clinical workflow and training. Future work will look at comparing the RPM and AlignRT deltas of breast DIBH patients treated with both systems.