A superior alternative to the conventional Varian two-marker RPM™ box for respiration monitoring

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Motivation
Studies have shown that respiratory surrogates for breast cancer patients are more representative for the target motion, when they are placed close to the target [1]. The existing Varian two-marker RPM™ box has a footprint which limits its positioning flexibility, therefore it can only be positioned stably below the breasts, i.e. around the xiphoid process. A novel respiratory motion surrogate, the Surrogate of Total Amplitude due to Respiration (STAR), was developed. STAR has a smaller footprint, allowing more freedom in its positioning i.e. closer to the target.

Purpose
The STAR is compared with the RPM box with focus on
• Surface dose enhancement in the patient
• Tracking of respiratory signal
• Clinical performance during treatment

Surface dose enhancement
Gafchromic EBT3™ film was placed on a 5 cm thick Solid Water™ backscatter block and irradiated with a 10 x 10 cm² 6 MV photon beam with and without the respiratory motion surrogates.
• Surface dose was enhanced by up to 45 % and 235 %
• Area of at least 25 % surface dose enhancement was 9.7 cm² and 71.7 cm².

Clinical performance
20 consecutive breast cancer patients, treated between November 2016 and February 2017 were retrospectively selected. All patients were treated in deep inspiration breath hold (DIBH) radiotherapy to 50 Gy in 25 fractions. 10 were monitored with the RPM box and 10 with the STAR.
• MV verification images of the medial field were acquired during treatment every 5th fraction. The last two fractions with MV verification images were selected (Typically the 16th and 21st) and rigidly registered to the DRR.
• Distance to agreement was measured and compared between the two patient groups. Mann-Whitney was used for statistical comparisons.
• No significant differences were found between the surrogates (p > 0.6).

<table>
<thead>
<tr>
<th></th>
<th>Vrt [mm]</th>
<th>Lng [mm]</th>
<th>Lat [mm]</th>
<th>3D [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>RPM box</td>
<td>-0.9 (1.6)</td>
<td>-1.2 (2.0)</td>
<td>0.1 (1.1)</td>
<td>3.6 (0.7)</td>
</tr>
<tr>
<td>STAR</td>
<td>0.4 (1.6)</td>
<td>-2.9 (1.4)</td>
<td>0.6 (0.9)</td>
<td>3.7 (1.1)</td>
</tr>
</tbody>
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Mean values and standard deviations of the distance to agreement of MV verification images are shown for the vertical, longitudinal, lateral directions and total distance.

Conclusion
The STAR respiratory motion surrogate has replaced the Varian RPM two-marker box in clinical use in our clinic due to its superior versatility in positioning, improved skin sparing and identical clinical performance.
The STAR surrogate has so far been used on (>200 breast, lymphoma and lung cancer patients), regardless of anatomy or reconstructive surgery.

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