3D spatial compounding with the Clarity® system:
Improving ultrasound image quality in gynaecological image-guided radiotherapy

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The uterus can be visualized with ultrasound

Ultrasonic (US) characteristics:
• Non-ionizing
• Non-invasive (transabdominal)
• Excellent soft-tissue contrast

Promising alternative to CBCT for daily adaptation of radiotherapy based on soft-tissue information.

Challenges in acquiring high quality transabdominal ultrasound images of the uterus
• Small bladder volume and high BMI → signal attenuation
• Small field of view

Research Question: Does 3D spatial compounding with the Clarity® System improve the quality of transabdominal ultrasound images of the uterus?

3D spatial compounding with Elekta Clarity® System

**Definition:** Average (mean) of at least 2 spatially registered* ultrasound image volumes to form a composite image

**Potential benefits:** Increase contrast to noise ratio (CNR), extend field of view, and reduce impact of image artifacts on composite image

*Clarity® probe-tracking hardware

Enables mapping of US images to room coordinates

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**Study Design**

<table>
<thead>
<tr>
<th>Cohort</th>
<th># individual US images</th>
<th># of time points per subject</th>
<th>Total compound 'sets' analyzed</th>
<th>Method for assessing image quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phantom (n = 1)</td>
<td>7</td>
<td>1</td>
<td>1</td>
<td>CNR, spatial resolution (FWHM of LSF)</td>
</tr>
<tr>
<td>Healthy Volunteers (n = 4)</td>
<td>6</td>
<td>4 – 6 (empty and full bladder)</td>
<td>21</td>
<td>Image ranking by 3 independent observers 1 (worst) – 6 (best)</td>
</tr>
<tr>
<td>Patients (n = 4)</td>
<td>4</td>
<td>1 – 6 (during treatment)</td>
<td>15</td>
<td>Image ranking by 3 independent observers 1 (worst) – 4 (best)</td>
</tr>
</tbody>
</table>

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**Phantom Study:**

Contrast to Noise Ratio (CNR) and spatial resolution results
Phantom Study Results: CNR

Phantom Study Results: Spatial Resolution

*In vivo studies:* Image quality measured by observer rankings
Image Rankings (n = 21)

* = significantly different than original image
= significantly different than neighbor

Observer Rankings: Cervical cancer patients

* = significantly different than original image
= significantly different than neighbor

Legend

CTV (uterus, cervix, and part of vagina)
Uterine fundus
External ostium
Summary

- Image compounding provides significant improvement in CNR (range of improvement from 35% - 104%)
- No significant differences in spatial resolution
- Image quality of uterus had significantly higher ranking in image compounds compared with the original image

Future Work:

- Investigate whether performance of segmentation algorithms is improved on compounded images compared with original images

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