A comparison of cone beam CT and different MR sequences for use in image guided radiotherapy for cervical cancer

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ABSTRACT

Purpose: Over the course of radiotherapy for cervical cancer, there can be significant motion of the cervix and uterus. This means that daily imaging of soft tissue, ideally on the radiotherapy couch, is required prior to radiotherapy to ensure coverage of the clinical target volume. The most commonly used 3D imaging technique is kilovoltage cone beam CT (kV CBCT.) Although kV CBCT is very useful for confirming patient set up based on bony anatomy, there are a number of limitations. The poor soft tissue contrast of kV CBCT means it is difficult to identify the boundaries between the cervix and uterus and other pelvic organs such as the bladder and rectum. A number of solutions have been developed to integrate MRI with radiotherapy delivery. Sequences for MR guided radiotherapy have different requirements to those for diagnostic imaging, as lower resolution may be adequate to allow faster acquisition and better anatomical coverage. The aim of this study is to subjectively assess the quality of kV CBCT and a variety of MR sequences, specifically for use in image guided radiotherapy.

Materials & Methods:

Three patients underwent daily CBCT and MR scans at three time points during external beam radiotherapy for cervical cancer. Patients were scanned on a 1.5T MRI scanner (MAGNETOM Aera; Siemens Healthcare, Erlangen, Germany) on a flat table top with a coil bridge in the radiotherapy planning position. T2 Turbo Spin Echo (TSE) as well as DIXON VIBE sequences were repeated at two time points during each scan. Table 1 provides details of the sequences assessed.
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**Table 1 - summary of MR sequences**

<table>
<thead>
<tr>
<th>MR Sequence Used</th>
<th>Planes acquired</th>
<th>Acquisition time (mm:ss)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3D DIXON VIBE (in-phase and water reconstruction)</td>
<td>Transverse</td>
<td>2:09</td>
</tr>
<tr>
<td></td>
<td>Coronal</td>
<td>1:44</td>
</tr>
<tr>
<td>2D T2 TSE</td>
<td>Transverse</td>
<td>1:04</td>
</tr>
<tr>
<td></td>
<td>Sagittal</td>
<td>1:01</td>
</tr>
</tbody>
</table>

All scans were rigidly registered to the patient’s planning CT and viewed using in house software. Scans were graded for overall utility using a 4 point scale between good to poor. Criteria considered included the ability to see soft tissue boundaries and the ability to contour the areas of interest. Identification of tumour was graded on a 4 point scale between clear and not visualised. A second observer assessed scans for one patient.

**Results:** A total of 105 scans were assessed (35 twice.) There was reasonable intra-observer agreement, with 87% agreement of overall scan quality with a cut off of fair or above. 35% CBCT images were assessed as good or fair for overall quality by at least one observer. 100% of MR scans were assessed as good or fair by both observers. Tumour was clearly or very clearly identified on 95% of T2 sequences but on no CBCT or DIXON VIBE sequences.

**Conclusions:** In contrast to Kv CBCT, all MR imaging sequences provided consistently good visualisation of the pelvic organs and were considered suitable for image guided radiotherapy. DIXON VIBE sequences provided excellent anatomical coverage and include the entire body contour but do not allow identification of the tumour. T2 sequences, optimized for acquisition speed, have limited coverage but allow accurate tumour identification in the majority of cases. This is not required for standard image guided radiotherapy but may allow for safe reduction of the clinical target volume.

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