The submission is to be considered in the following category
- Oral presentation preferred
- Poster presentation only

Trainee status
- I am a trainee (student or postdoctoral fellow)
- I wish to be a candidate for best student paper/poster

**PRESENTATION TITLE**
4D-T2w MRI on an MR-linac

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**ABSTRACT**

**Purpose:**
To employ a super-resolution reconstruction (SRR) to calculate 4D-T2w MRI from low-resolution 2D-T2w MRI that was dynamically acquired on an MR-linac.

**Materials & Methods:**
Five healthy volunteers were scanned in free breathing at 1.5 T on an MR-linac (Elekta AB, Stockholm, Sweden) with a 2D-T2w turbo spin echo (TSE) sequence which was interleaved with a 1D liver-dome navigator (orientation: sagittal and coronal, voxel-size: 1.5x1.5x5 mm³, in-plane field-of-view: 264x384 mm², 50 slices, 10 dynamics, acquisition time: 9.6 minutes). For comparison, three volunteers were additionally scanned with a radial golden-angle 3D-T1w stack-of-stars spoiled gradient echo sequence (orientation: axial, voxel-size: 1.5x1.5x3 mm³, field-of-view: 384x384x200-288 mm³, acquisition time 7 min) and a 3D-T2w TSE sequence (orientation: axial, voxel-size: 1.5x1.5x3 mm³, field-of-view: 384x384x264 mm³, acquisition time: 9 min), which was gated to exhalation.

To calculate super-resolution 4D-T2w (4D-T2wSR) MRI, an initial guess (i4D-T2w MRI) was obtained by sorting the coronal and sagittal slices using the navigator signal into 8 respiratory phases. Stitching artefacts were reduced by smooth 3D registration of the exhalation phase to all other phases in the i4D-T2w MRI; generating a stitching artefact-free 4D-T2w (s4D-T2w) MRI. Afterwards, i4D-T2w MRI was registered on a slice-by-slice basis to the corresponding respiratory phase in the s4D-T2w MRI, resulting in corrected 4D-T2w MRI. This process was repeated separately for both the coronal and sagittal slices. The phases of the sagittal and coronal corrected 4D-T2w MRI were transformed to
midposition [1], averaged and served as input for SRR [2]. 4D-T2w<sup>SR</sup> MRI was obtained by transforming the SRR results using motion information calculated from the coronal corrected 4D-T2w MRI [3].

4D-T2w<sup>SR</sup> was compared to 4D-T2w<sup>MVFP</sup> MRI, which was obtained by transferring the motion information from 4D-T1w (reconstructed using the XD-GRASP algorithm [4]) to 3D-T2w MRI [3]. To assess whether motion information was retained in 4D-T2w MRI, the liver-dome position in each respiratory phase of 4D-T2w MRI was calculated using an edge-detection method [3] and was compared to the displacement recorded by the 1D navigator acquisition.

**Results:**
4D-T2w<sup>SR</sup> MRI (1.0x1.0x1.0 mm<sup>3</sup>) displayed greater image sharpness than 4D-T2w<sup>MVFP</sup> MRI (1.5x1.5x3.0 mm<sup>3</sup>, 8 phases) (Figure. 1), possibly because 4D-T2w<sup>MVFP</sup> MRI was reconstructed at a lower resolution. When compared to the range of the respiratory cycle obtained from the navigator acquisition (Table. 1), 4D-T2w<sup>SR</sup> MRI exhibited over-regularisation of motion. An average difference of 2 mm between the ranges of respiratory motion obtained from 4D-T2w<sup>SR</sup> and 4D-T2w<sup>MVFP</sup> MRI was found, demonstrating good agreement. Remaining differences might be due to changes in respiratory pattern during acquisition. Both methods might be further accelerated to a clinical-time frame by optimization of parallelizable components.

**Table. 1:** Comparison between the range of motion from 4D-T2w<sup>MVFP</sup> (MVFP), 4D-T2w<sup>SR</sup> (SR) and the 1D liver-dome navigator signal.

<table>
<thead>
<tr>
<th>Volunteer</th>
<th>MVFP (mm)</th>
<th>SR (mm)</th>
<th>1D Navigator (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10.1</td>
<td>8.7</td>
<td>17.8</td>
</tr>
<tr>
<td>2</td>
<td>11.6</td>
<td>8.2</td>
<td>14.7</td>
</tr>
<tr>
<td>3</td>
<td>4.1</td>
<td>5.3</td>
<td>12.5</td>
</tr>
<tr>
<td>4</td>
<td>NA</td>
<td>9.8</td>
<td>20.7</td>
</tr>
<tr>
<td>5</td>
<td>NA</td>
<td>4.2</td>
<td>13.9</td>
</tr>
</tbody>
</table>

Figure. 1: Comparison of 4D-T2w (4D-T2w<sup>MVFP</sup>) and super-resolution 4D-T2w (4D-T2w<sup>SR</sup>) MRI for volunteer 2.

**Conclusions:**
4D-T2w MRI can be obtained on an MR-linac to assist treatment delivery for anatomy undergoing respiratory motion.

**References:**