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### PRESENTATION TITLE
Dose escalation in head and neck cancer using high-field MRI-linac techniques

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### ABSTRACT
Dose escalation in head and neck cancer using high-field MRI-linac techniques

**Purpose:**
High-field hybrid MRI-linac systems may allow assessment of intratumoral radioresistance, e.g. tumour hypoxia, using functional MR techniques. In this study, we investigate the feasibility of hypoxia-PET based dose escalation (DE) in head and neck cancer (HNC) patients with a high-field MRI-linac and to compare treatment plan quality of DE applied with the MR-linac and a standard linac.

**Materials & Methods:**
Ten patients with locally advanced HNC who received dynamic FMISO PET/CT scans and a treatment planning CT prior to definitive radio-chemotherapy in a phase II dose escalation trial were retrospectively included in this study. Two treatment plans were created for each patient with Monaco Research 5.19.03 (Elekta AB, Stockholm Sweden) using the same patient model and fractionation scheme with 30×2 Gy and 30×1.8 Gy in the PTV\(_{60}\) and PTV\(_{50}\), respectively and a sequential boost of 5×2 Gy in the PTV\(_{70}\). Dose was escalated to 2.2 Gy for all fractions in hypoxic sub-volumes (HV) of the...
PTV<sub>70</sub> identified by dynamic FMISO PET. Delineations of HVs were available from the original treatment plan.

For the standard linac, VMAT plans with two full arcs were created. For the MRI-linac (Elekta AB, Stockholm Sweden), Step-and-Shoot (SNS) plans with nine beams were created with automatically optimized beam angles based on the angular MU distributions in the corresponding VMAT plan. Specifications of both treatment units are given in Tab. 1. Treatment plans were optimized to show similar mean doses in the PTV<sub>70</sub>. Typical dose parameters were compared between the two plans using a Wilcoxon signed rank test in R 3.4.3.

A conformity index with respect to dose escalation (CI<sub>esc</sub>) was calculated by normalizing V<sub>95%</sub> to V<sub>98%</sub> of the escalation dose to account for potential differences in dose coverage of the two techniques.

**Results:**

For both techniques, it was generally possible to create plans adhering to our internal guidelines, though compromises were slightly more frequent for MRI-linac plans, e.g. with respect to D<sub>max</sub> in the mandible. Hypoxia dose escalation as per study protocol was possible for MRI-linac plans, with a median D<sub>mean</sub> of 75.4 Gy in the escalation volume. MR- and standard linac plans showed similar coverage of the escalation volume with a mean difference of 0.02 Gy in D<sub>mean</sub> (<i>p</i>=0.85). However, significantly lower median CI<sub>esc</sub> values of 0.081 and 0.119 were found for MR-linac and standard linac plans (<i>p</i>&lt;0.01). Due to the lower conformity, also for PTV<sub>70</sub> a small median D<sub>mean</sub> increase (0.20 Gy, <i>p</i>=0.19) was found in MRI-linac plans. This trend persists in a significant increase for PTV<sub>60</sub> (0.83 Gy, <i>p</i>&lt;0.01) and PTV<sub>54</sub> (0.64 Gy, <i>p</i>&lt;0.01).

Figure 1 shows differences for all relevant dosimetric parameters. Only in the right parotid gland a significant median increase in D<sub>median</sub> of 2.02 Gy (<i>p</i>&lt;0.01) was found for MRI-linac plans. Further differences were observed in OARs with lower priority, e.g. a median increase in mandible D<sub>max</sub> of 1.12 Gy (<i>p</i>=0.03).

![Figure 1: Boxplots showing differences between dose parameters in target volumes and major organs at risk. Positive values indicate an increased dose in MRI-linac plans.](image-url)
Conclusions:
Treatment planning for definitive radio-chemotherapy of locally advanced HNC patients including a 10% dose escalation in hypoxic tumour sub-volumes appears feasible with the current high-field MRI-linac technology. MRI-linac plans are slightly less conformal and show slightly inferior OAR sparing, which may in the future be compensated by margin reduction due to daily MR-based adaptive radiotherapy and implementation of VMAT.

<table>
<thead>
<tr>
<th></th>
<th>MR-linac</th>
<th>Standard linac</th>
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<tbody>
<tr>
<td>Magnetic field (T)</td>
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</tr>
<tr>
<td>Photon energy (MV)</td>
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<td>6</td>
</tr>
<tr>
<td>Leaf width (mm)</td>
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<td>5</td>
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<tr>
<td>Focus-isocentre (cm)</td>
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<td>100</td>
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<td>Flattening filter</td>
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<td>Collimator angle (°)</td>
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<td>Step-and-Shoot</td>
<td>VMAT</td>
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<td>XVMC</td>
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<td>Centre of PTV70</td>
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<tr>
<td>Other</td>
<td>MR cryostat</td>
<td>MR receiver coil</td>
</tr>
</tbody>
</table>

Table 1: Treatment unit specific parameters used for treatment planning