The influence of MRI scan position on oropharyngeal radiotherapy patients

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Introduction

• RT: accurately define GTV & its relationship to OAR

• MRI is the imaging modality of choice for oropharyngeal patients\(^1\)

• Improved soft tissue contrast; reduced artefacts from dental amalgam

• If MRI not acquired in RT position registration with CT results in misalignment\(^2\)

• Does this misalignment affect target volume definition/RT planning?


Study plan

• Ethical approval granted by local ethics committee
• 22 oropharyngeal RT patients
• Planning CT
• 2 MRI scans (1.5T):
  – MRI$_{RT}$
  – MRI$_{D}$
• Is it necessary to perform CT-MRI$_{RT}$ or would CT-MRI$_{D}$ be sufficient?
Materials: $\text{MRI}_{\text{RT}}$ set-up

- 4-ch cardiac coil
- Flat table
- Loc-bar
- Base-plate
- Immobilisation mask

GE Healthcare, MRI Oncology Table, WI, USA
Method: CT-MR registration

Eclipse, Varian Medical Systems, Inc. CA, USA version 10.0.39
Method: Effects on GTV

• Clinicians were given anonymised radiologist reports and asked to contour GTV

• Delineated GTV for each patient in 3 ways:
  1. CT with MRI$_D$ on another console $\Rightarrow$ GTV$_C$
  2. Registered CT-MRI$_D$ $\Rightarrow$ GTV$_D$
  3. Registered CT-MRI$_{RT}$ $\Rightarrow$ GTV$_{RT}$

• $\geq$ 1 week between contouring same patient & blinded to previous delineations
Method: Dosimetric effects

- GTV and CTV LR were grown to PTV and PTV LR using standard clinical protocol for each set-up (defined as PTV\textsubscript{C}, PTV\textsubscript{D}, PTV\textsubscript{RT})

- VMAT plans were calculated by optimising for PTV and PTV LR and minimising dose to OARs

- Mean DVHs were generated for PTV\textsubscript{C}, PTV\textsubscript{D}, PTV\textsubscript{RT}

- Our working hypothesis was that PTV\textsubscript{RT} was the gold standard

- So mean DVHs were calculated optimising for PTV\textsubscript{C}, PTV\textsubscript{D} but investigating the dose coverage of PTV\textsubscript{RT}
Results: Quality of registration

CT-MRI$_D$ registration
Results: Quality of registration

CT-MRI\textsubscript{RT} registration
Results: Quality of registration

Mean distance from centre of the CT structures (mm)

Mean dist: 9.1mm MRI_D; 2.9mm MRI_{RT} (p value < 0.0001)
Results: Effects on GTV

Mean GTV Volume (cm³)

- $\text{GTV}_C$: 44.1
- $\text{GTV}_D$: 33.7
- $\text{GTV}_{RT}$: 30.5

$p$ value: $\text{GTV}_D = 0.027; \text{GTV}_{RT} = 0.014$
Results: Dosimetric effects

Ratio of total structure vol (%)

PTV for which VMAT plan was optimised

PTV for which VMAT plan was optimised

PTV investigated

PTV_C

PTV_D

PTV_{RT}

PTV_C

PTV_D

PTV_{RT}
Results: Dosimetric effects

PTV for which VMAT plan was optimised

PTV investigated

PTV<sub>C</sub>  PTV<sub>RT</sub>

PTV<sub>D</sub>  PTV<sub>RT</sub>

PTV<sub>RT</sub>  PTV<sub>RT</sub>
## Results: Dosimetric effects

<table>
<thead>
<tr>
<th>Ratio of total PTV volume (%)</th>
<th>Dose constraint (%)</th>
<th>$PTV_C$</th>
<th>$PTV_D$</th>
<th>$PTV_{RT}$</th>
<th>$PTV_C : PTV_{RT}$</th>
<th>$PTV_D : PTV_{RT}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>99 %</td>
<td>&gt; 90</td>
<td>90.8</td>
<td>91.4</td>
<td>90.9</td>
<td>58.8</td>
<td>14.9</td>
</tr>
<tr>
<td>95 %</td>
<td>&gt; 95</td>
<td>95.3</td>
<td>95.7</td>
<td>95.3</td>
<td>84.7</td>
<td>66.2</td>
</tr>
<tr>
<td>5 %</td>
<td>&lt; 105</td>
<td>104</td>
<td>104.4</td>
<td>104</td>
<td>103.8</td>
<td>104.1</td>
</tr>
<tr>
<td>2 %</td>
<td>&lt; 107</td>
<td>105.7</td>
<td>105.4</td>
<td>105.1</td>
<td>104.7</td>
<td>105.1</td>
</tr>
</tbody>
</table>
Conclusion

• There is a significant improvement in CT-MRI\textsubscript{RT} versus CT-MRI\textsubscript{D} (\(p\) value < 0.0001)

• GTV\textsubscript{C} was significantly larger than GTV\textsubscript{D} (\(p\) value = 0.027) or GTV\textsubscript{RT} (\(p\) value = 0.014)

• When optimising for PTV\textsubscript{C} or PTV\textsubscript{D} using VMAT but calculating the dose coverage of PTV\textsubscript{RT} not all clinical dose constraints were met

• The optimal imaging protocol is to use CT-MRI\textsubscript{RT} for VMAT planning of patients with oropharyngeal cancer
Acknowledgements

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