Introduction and Objectives

- For localized prostate cancer patients, reduced CTV-to-PTV margins have been linked to reduced toxicity.¹,²
- However, with reduced margins, loss of target coverage may become more prominent, particularly over the course of radiation therapy.
- This work uses deformable image registration (DIR) based cumulative dose to track actual (delivered) dose to targets and organs at risk (OAR) to determine the impact of reduced margins on:
  - Dosimetric endpoints
  - Prospectively acquired quality of life (QOL)

Methods: Dose Accumulation

- Under an IRB-approved protocol, 20 prostate cancer patients were evaluated
  - 11 control patients with standard margins (10 mm uniform with 6 mm at prostate/rectum interface)
  - 9 patients with reduced planning margins (5 mm uniform with 4 mm at prostate/rectum interface)
- To mitigate known limitations associated with CBCT images, Planning CT of each patient was deformably resampled to each daily CBCT using a parameter optimized¹⁴ Elastic B-spline DIR algorithm for dose of the day calculations
- Dose of the day was then accumulated on the planning CT for all fractions, using energy-mass mapping based on the Elastic transformation. Full adaptive radiotherapy (ART) workflow is shown in Figure 1.

Results: QOL Correlations to Hot Spots in OAR

<table>
<thead>
<tr>
<th>Target/OAR</th>
<th>Reduced Margin (OAR)</th>
<th>Standard Margin (OAR)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>D_{\text{mean}}</td>
<td>D_{\text{mean}}</td>
</tr>
<tr>
<td></td>
<td>Delivered</td>
<td>Planned</td>
</tr>
<tr>
<td>PTV</td>
<td>78.0±0.32</td>
<td>80.2±0.61</td>
</tr>
<tr>
<td>Prostate</td>
<td>80.9±0.42</td>
<td>80.6±0.44</td>
</tr>
<tr>
<td>Bladder</td>
<td>33.7±9.50</td>
<td>34.1±10.2</td>
</tr>
<tr>
<td>Rectum</td>
<td>33.0±3.49</td>
<td>33.1±5.6</td>
</tr>
<tr>
<td>SV</td>
<td>74.5±4.93</td>
<td>78.1±5.6</td>
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</tbody>
</table>

Table 1: Mean ± SD. Dose accumulation volumes and dose metrics for the two groups

- D_{\text{mean}}, D_{\text{mean}}, and D_{\text{mean}} values were not statistically different between the groups (p>0.1). However, the standard margin group has larger PTV/bladder and PTV/rectum intersection volumes (Table 3).
- This suggests that the hot spots in the bladder and rectum are significantly smaller for the margin-reduced group, which may contribute to the improvement in QOL scores. A typical patient from each group is shown in Figure 2.
- The PTV/rectum intersection volume shows a moderate correlation to the bowel EPIC domain (Pearson’s coefficient = -0.51).

Conclusions

- Daily deformable dose accumulation shows that deviation of the cumulative (delivered) dose from planned dose is minimal. Lowering the margin to 5/4 mm does not affect the clinical deliverability of the plan.
- Early QOL results from the first 20 patients (9 margin reduced and 11 control) shows that there is a clinically meaningful difference in QOL for the margin reduced group.
- A larger number of patients and greater follow-up is needed to draw unequivocal conclusions.

Limitations and Future Directions

- More patients and longer follow ups needed. Trial will continue until protocol goals (30 patients in each arm, 60 total) are met. Currently median QOL follow up time is 24 months for the 20 patients studied. Follow ups will continue for 5 years post-RT for each patient.
- Better correlations between QOL and dosimetric parameters are expected with more patients and longer follow-ups.

References

2. Sandler et al. Urology 2010
5. Szynalski et al. Urology 2010

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