Hybrid MLC and couch tracking

J. Toftegaard1, R. Hansen1, K. Macek1, P.R. Poulsen1
Aarhus University Hospital, Department of Oncology, Aarhus C, Denmark
1Varian Medical Systems, Imaging Laboratory, Baden, Switzerland

Purpose or Objective: MLC and couch tracking are promising techniques for interfractional tumor motion management. However, both techniques have their limitations that result in residual dosimetric errors: MLC tracking perpendicular to the MLC leaves is limited by the finite MLC leaf width, while couch tracking has slower dynamics than the MLC and might be uncomfortable for the patient. Here, we suggest a range of potential hybrid MLC-couch tracking strategies and test the performance of each strategy with extensive tracking simulations.

Material and Methods: Three hybrid MLC-couch tracking strategies were investigated and compared with pure MLC tracking and pure couch tracking. Dividing the target motion into motion parallel and perpendicular to the MLC leaves in beam’s eye view, the investigated tracking strategies were as follows (in order or increasing MLC tracking fraction): 1) Pure couch tracking; 2) Couch for all perpendicular target motion and MLC for parallel motion; 3) Couch for perpendicular motion below one leaf width and MLC for the remaining motion; 4) Same as 3) except that the couch only adapts to stable perpendicular shifts with standard deviation below 0.5mm during the last second; 5) Pure MLC tracking.

The current developer release of TrueBeam tracking system does not allow for hybrid MLC-couch tracking, but our in-house built tracking simulator allowed investigation of the hybrid strategies. The simulator was experimentally validated to mimic the TrueBeam MLC and couch tracking system. Tracking treatments with each tracking strategy were simulated for 160 lung tumor and 695 prostate trajectories. A high and a low modulated VMAT treatment (1 arc) with MLC motion in the superior-inferior direction were simulated for each trajectory. The tracking performance of each simulated treatment was quantified as the mean MLC exposure error in beam’s eye view. The MLC exposure error is the sum of under-exposed areas Au (MLC shielded areas that should ideally be exposed) and over-exposed areas Ao (MLC exposed areas that should ideally be shielded). Au + Aoa has previously been shown to be a good surrogate for dosimetric errors in tracking treatments.

Results: The figure shows the cumulative distribution of mean MLC exposure errors for all trajectories and for trajectories with large motion (>3mm for prostate, >5mm for lung). The table shows the median reduction in the exposure error relative to pure MLC tracking as well as the mean 3D couch speed for all tracking strategies.

<table>
<thead>
<tr>
<th>Motion</th>
<th>Prostate all &gt;3mm</th>
<th>Lung all &gt;5mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Couch</td>
<td>42.31% 80.92%</td>
<td>42.31% 37.69%</td>
</tr>
<tr>
<td>(2)</td>
<td>48.78% 81.67%</td>
<td>48.78% 45.90%</td>
</tr>
<tr>
<td>(3) 0.02%</td>
<td>42.78% 73.98%</td>
<td>42.78% 36.35%</td>
</tr>
<tr>
<td>(4) 0.00%</td>
<td>33.94% 68.57%</td>
<td>33.94% 29.05%</td>
</tr>
<tr>
<td>(5) MLC</td>
<td>0.00% 0.00%</td>
<td>0.00% 0.00%</td>
</tr>
</tbody>
</table>

Table 1: Upper part: Median reduction in percent of mean exposure error relative to pure MLC tracking. Lower part: Average couch speed.

Conclusion: Hybrid MLC-couch tracking offers a continuum of trade-offs between tracking accuracy and couch motion. A modest degree of couch tracking (strategy 4) largely improved MLC tracking, especially for prostate motion exceeding 3mm. Couch tracking perpendicular to the MLC leaves and MLC tracking parallel to the leaves (strategy 2) gave the most accurate tracking and a large couch motion reduction compared to pure couch tracking.

OC-0215

Mapping of breathing and cardiac induced motion of lymph node targets in lung cancer patients
M.L. Schmidt1, L. Hoffmann2, M. Knap1, T.R. Rasmussen1, B.H. Følkersen1, J. Toftegaard1, D.S. Møller1, P.R. Poulsen1
1Aarhus University Hospital, Department of Oncology, Aarhus C, Denmark
2Aarhus University Hospital, Department of Medical Physics, Aarhus C, Denmark
3Aarhus University Hospital, Department of Pulmonology, Aarhus C, Denmark

Purpose or Objective: Malignant mediastinal lymph nodes (LNs) are often included in the planning target volume for lung cancer patients (pts), but LN motion is not well investigated and this may potentially undermine the locoregional control. LNs in the mediastinum are difficult to visualize in cone-beam CT (CBCT) scans. In this study, the position of implanted fiducial markers obtained from daily CBCT projections was used to map the 3D intrafraction and interfraction motion of LN targets throughout the treatment course for ten lung cancer pts.

Material and Methods: Ten lung cancer pts with Visicoil fiducial markers implanted in LN targets by EBUS bronchoscope received intensity modulated radiotherapy (RT) treatment in 30-33 fractions. A total of 26 LN targets with Visicoils were analyzed. A pre-treatment setup CBCT scan with ~675 projections was used for daily online soft tissue match on the primary tumor (GTV-T). The Visicoil positions were segmented offline in each projection using a semi-automatic template-based algorithm. From the segmented Visicoil positions the 3D Visicoil trajectories were estimated with 11Hz sample rate by a probability-based estimation method. By frequency analysis, the 3D trajectories were separated into a cardiac and a breathing component. The motion ranges of the Visicoils were extracted in the left-right (LR), cranial-caudal (CC) and anterior-posterior (AP) direction for the total motion, as well as the separated cardiac and breathing induced motions. Also, the daily mean setup error of the Visicoils after the GTV-T soft-tissue match was extracted and used to calculate motion margins required for interfraction baseline shifts of the LN targets (using the formula $2\Delta + 0.7\sigma$).

Results: The 2.98 percentile motion ranges, for the patient group were in mean (with standard deviation) 2.1mm (0.5mm)(LR), 7.3mm (2.6mm)(CC), 3.3 mm (1.3mm)(AP). The cardiac induced mean motion ranges were 1.3mm (0.7mm)(LR), 1.3mm (0.6mm)(CC), 2.3mm (1.5mm)(AP). The figure shows the averaged waveform in the coronal plane of the cardiac and breathing motion components of each Visicoil at the first RT fraction. The waveforms were obtained by averaging over a number of breathing/cardiac cycles.
Breathing motion was largest in the CC direction and more prominent for more caudal LNs. Cardiac induced motion was often (77%) largest in the AP direction (not shown) and tended to be largest for more cranial LNs, occasionally (44 %) being the dominant motion component. The daily baseline shifts from all fractions resulted in interfraction motion margins of 4.9mm(LR), 4.7mm(CC), and 6.4mm(AP).

**Conclusion:** The motion of Visi coils in projection images of daily CBCTs was used to map and analyze intrafraction and interfraction motion of mediastinal LNs. While the motion was governed by breathing induced motion, the most cranial LNs had substantial cardiac induced motion.

* Van Herk et al. Errors and margins in radiotherapy. 2004

**Symposium:** Head and neck: reduction of margins and side effects

**SP-0217**

The ESTRO perspective - a guideline for positioning of head and neck patients

M. Mast1, M. Leech1, M. Coffey2, F. Moura3, A. Ostavics4, D. Pasini5, A. Vaandering6

1Haaglanden Medical Centre Location Westeinde Hosp, Den Haag, The Netherlands

2Trinity College Dublin, University of Dublin, Dublin, Ireland

Republic of

3Hospital Cuf Descobertas, Radiotherapy, Lisbon, Portugal

4General Hospital Vienna AKH Wien, Radiotherapy, Vienna, Austria

5Policlinico Universitario Agostino Gemelli, Radiotherapy, Rome, Italy

6UCL Cliniques Univ. St. Luc, Radiotherapy, Brussels, Belgium

**Purpose:** These guidelines have been developed to assist Radiation Therapists (RTTs) in positioning, immobilisation, position verification and treatment for head and neck cancer (HNC) patients presenting for radiation therapy.

**Methods and materials:** A critical review of the literature was undertaken by the authors, searching relevant databases including PubMed, Embase and Google Scholar. Search terms used included combinations of and Boolean operations on ‘head and neck cancer’, ‘radiation therapy’, ‘radiotherapy’, ‘positioning’, ‘immobilisation’, ‘verification’, ‘cone beam CT’, and ‘electronic portal imaging’. Studies in English, French, Portuguese, Italian and German were included. Based on the literature review, a survey was developed to ascertain the current positioning, immobilisation and position verification methods for head and neck radiation therapy across Europe. The survey consisted of 40 questions, divided into 5 sections. The sections contained both open and closed questions on: Demographics, Patient Positioning, Immobilisation devices, CT/Simulation Practice, Position Verification as well as elements of quality assurance (QA) in relation to positioning and immobilisation. Data analysis was performed using SPSS Statistics version 20.0 (IBM SPSS Statistics for Windows. Armonk, NY: IBM Corp.). Descriptive statistics were calculated and appropriate figures and tables constructed. Cross tabulations were performed where appropriate to maximise data analysis.

**Results:** Results from the European-wide survey indicated that a wide variety of treatment practices and treatment verification protocols are in operation for head and neck cancer patients across Europe currently. These ranged from 3DCRT to VMAT and from daily online CBCT imaging to offline correction protocols using KV EPDs or in some cases, MV portal imaging. In terms of immobilisation, the majority of respondents use thermoplastic masks in their immobilisation of head and neck patients, with some variance in how shoulder position is maintained. The full results from this survey are available in the complete guideline document, available on the ESTRO website. Guidelines were given for: Positioning prior to thermoplastic mask construction, Construction of thermoplastic mask, The CT procedure, Treatment Verification and delivery, Match Structures for Image Verification.

**Conclusion:** The preparation of this guideline document has demonstrated that although there have been substantial changes in the set up, positioning, immobilisation and verification of head and neck cancer patients over the last number of years across Europe, significant variations still exist. These variations can be attributed to differences in resource type and quality, institutional protocols as well as considerable differences in education level of radiation therapy professionals across Europe. RTTs must be aware of the potential dosimetric impact of poor positioning and immobilisation and/or position verification procedures as well as their influence on required margins for HNC radiation therapy. These guidelines have been developed to provide RTTs with guidance on positioning, immobilisation and position verification of HNC patients. The guidelines will also provide RTTs with the means to critically reflect on their own daily clinical practice with this patient group.

**SP-0216**

Contouring of normal tissues in head and neck radiotherapy

S. Hol

Dr. Bernard Verbee ten Instituut, Tilburg, The Netherlands

In the head and neck region, there are a lot of organs at risk (OAR) to take into account when making a treatment plan. The radiation fields are often very large and can go up to the brain and down to the lungs. The OAR in this region are responsible for a lot of body functions, like walking, talking, swallowing and taste. Some of the OAR are parallel organs, so they will be able to compensate the loss of part of the organ and others are serial organs, which implies that the dose to the entire organ has to be below a threshold value in order to maintain the functionality.

In recent years most hospitals have started delineating more OAR in the head and neck region, but for some, there is no consensus on the constraints that have to be applied. Recently, consensus guidelines for head and neck OAR delineation were defined by Brouwer et al (1). To make sure that in the future we will be able to define constraints for these OAR we need a lot of data. This can only be obtained if there is consensus among institutes on delineation and reporting in the same manner.

In this presentation the different OAR will be discussed and a short summary of recently published guidelines will be provided.