Results: The inter-scan positional shifts and differences of rotation angles for each subject were averaged. The means and standard deviations of these averaged values were reported in the table (mean ± SD). For all VOIs, the shift in each direction was within ±1.5 mm. Generally, PGs and EBs presented larger shift and variability than PIT and BS, attributed to their superficial location, possibly greater freedom of mobility and/or deformation under immobilization. The rotation was within ±1.5° except for yaw of BS, which was explained by its short coronally projected distance from PIT. The SD of SI shift for all tissues was notably larger than other directions. This might result from the dockable couch design of the MR-sim and the open-face immobilization used.

Conclusion: MR-sim enables the possibility of inter-fractional soft tissue positional verification in HN. Our preliminary results suggested that PGs and EBs could present larger inter-fractional positional shift and variability than BS and PIT. Further study on the improvement of SI positional repeatability is warranted.


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Retrospective Review of HDR SAVI Breast Cases
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Purpose/Objective(s): Retrospective review of 15 HDR SAVI breast cases to evaluate our standardized procedure and plan quality.

Materials/Methods: Our clinic recently started an HDR SAVI breast program. To enhance planning and treatment efficiency while achieving a robust assessment for device integrity and rotation, we prepared in advance: procedures and checklists for simulation, independent plan checks and treatment delivery; and templates for structures, isodose levels, optimization constraints, and plan report. On the simulation day, the patient is immobilized and SAVI lumens are checked to ensure a clear pathway and appropriate length. The device’s white ring is marked in the direction of an applied tattoo, from which the distance to the device handle is measured. These values are used as baseline for the pretreatment initial assessment of the device rotation/depth (tolerance 3/5 mm, respectively). The CT simulation for planning is acquired with 2 mm slice thickness using a deep inspiration breath hold (DIBH) technique. The patient is then moved to a conventional simulator room where the HDR unit resides. Two digital radiographic images (used as pretreatment baseline) are acquired using DIBH. The angle for the first view is selected such that the SAVI device is projected along its long axis. Long/short diameters and distances between the markers located in channels 2, 4, 6 are measured (tolerance 3 mm). The second view is acquired at a near-orthogonal angle, chosen such that the markers are visible, and the distances between them are measured. The angles in the triangle defined by the three markers are computed for both views. Tolerance is set to 7°, which was estimated to correspond to a < 2° SAVI device rotation.

Results: This study is a review of 15 HDR SAVI breast cases for which the checklists/procedures above were followed. For each case the cavity to skin and rib distances were recorded and air/seroma contours to evaluate patient eligibility. The prescription dose was 34 Gy in 10 fractions. The established DVH criteria were successfully met for all plans (PTV_Eval % V90-90%<air-seroma ≥ 90%; V150/200 ≤ 50/20 cc; skin/ribs D0.1cc ≤ 125%/145% Rx). For these 15 cases, the cavity to skin/ribs distances ranged 1-23 mm and 3-34 mm, and many cases required variable loading of the peripheral channels to reduce skin/rib dose, hence the importance of a robust rotation assessment. The changes in long/short diameters and distances between markers were ≤ 3 mm. The change in angles in the triangle defined by the markers was < 7° for one or both views. Larger angular changes were associated with breathing variations and shorter inter-marker distances.

Conclusion: The review of these cases demonstrated that the use of a standardized procedure and relevant checklists resulted in consistent results. There was no need to rescan or re-plan any patient, due to the robust rotation assessment.


3385

Dosimetric Comparison of Involved Field Irradiation and Elective Nodal Irradiation for Thoracic Esophageal Squamous Cell Carcinoma
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Purpose/Objective(s): The definition of nodal irradiation volume for thoracic esophageal squamous cell carcinoma is a controversial topic. Elective nodal irradiation (ENI) has always been criticized for extended-volume irradiation resulted in high rate of treatment related toxicity. However, with an introduction of IMRT, dosimetric impact of elective nodal irradiation was not clear compared to involved field irradiation (IFI). This study aims to compare the dose distribution to targeted volume and organs at risk in IMRT plans using ENI or IFI for thoracic esophageal squamous cell carcinoma.

Materials/Methods: The CT scan datasets of 40 consecutive patients with locally advanced thoracic esophageal squamous cell carcinoma were collected. For each case, two clinical target volumes (CTV-ENI and CTV-IFI) were contoured separately. CTV-ENI was defined according to the location of primary tumor. Lymph node stations 1, 2, 4, 5, 7 and other positive areas were included for upper thoracic esophageal tumor, lymph node stations 2, 4, 5, 7 and other positive areas were included for middle thoracic esophageal tumor, and lymph node stations 4, 5, 7, 16, 17 and other positive areas were included for lower thoracic esophageal tumor. CTV-IFI included the involved lymph node stations only. Two IMRT plans were generated for all 40 cases (plan-ENI and plan-IFI). The plan objective was to deliver 66Gy to PTV-GTV and 52.8Gy to PTV-CTVln in 33 fractions. Dose—volume histogram statistics, conformal index (CI), and homogeneity index (HI) were analyzed to compare treatment plans.

Results: The mean dose (D50), maximum dose (D2) and minimum dose (D98) of PTV-GTV were 6785.798±112.371cGy, 7067.165±168.682cGy and 6163.810±112.371cGy for ENI plans; 7067.165±168.682cGy, 7080.806±150.992cGy and 6093.175±155.665cGy for IFI plans. Respectively, no difference was identified between ENI plans and IFI plans (P>0.05). Homogeneity index (HI) (0.1327±0.0397 vs 0.1454±0.0333, P>0.05) and conformity index (CI) (0.9756±0.0132 vs 0.9735±0.0099, P>0.05) were comparable among both strategies. For organs at risk, IFI plans decreased significantly the Dmean, V5, V10, V20 and V30 of all lungs and the Dmean, VM3, and V30 of heart, the Dmax of spinal cord compared to ENI plans (P<0.05).

Conclusion: For locally advanced thoracic esophageal carcinoma, IMRT plans using either ENI or IFI could be accomplished with acceptable target coverage and OAR sparing. The IFI can reduce significantly the irradiation volume and mean dose of OARs. Our ongoing clinical study will evaluate the efficacy and treatment-related toxicity of ENI and IFI.

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3386

Quantification of Interobserver Variability in Image Registration Using Cone-beam CT for Partial Bladder Radiation Therapy
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Purpose/Objective(s): The use of cone beam CT (CBCT) and lipiodol for image registration to localize the target and derivate patient-specific
planning target volume (PTV) has improved the quality of partial bladder radiation therapy by increasing treatment precision and by reducing irradiated volume. For patients who are contraindicated for Lipiodol injection, soft tissue surrogates must be used for daily image guidance. Bladder Wall Surface where the tumor resides (BWS) and Center of Bladder (COB) are two such image registration surrogates. This study assessed the interobserver variability of these 3 image registration surrogates.

**Materials/Methods:** Following research ethics board approval, 7 observers were prospectively recruited to manually register 5 CBCTs from each of 20 bladder cancer patients with Lipiodol injected for tumor demarcation. Lipiodol, BWS and COB were used to register the CBCT to pre-treatment reference images, and displacement values in 3 directions were collected. Standard deviations (SD) of the 7 observations for an individual image were calculated to quantify variation between observers. The absolute displacements measured using COB and BWS were then compared to those using Lipiodol.

**Results:** 6300 displacement values were collected for analysis. Using Lipiodol resulted in the highest interobserver agreement, with a statistically significantly smaller SD than BWS in all directions (p < 0.005) or COB in the superior-inferior and anterior-posterior directions (p < 0.004). However all differences were less than 1 mm. Of the 3 directions, greatest variability was observed in the superior-inferior direction. Registration using COB had a larger absolute difference from Lipiodol (median 2.0 – 3.0 mm difference), when compared to BWS (median 1.1 – 2.0 mm difference).

**Conclusion:** Interobserver variability was comparable among the 3 image registration surrogates, but accounting for larger variation in the superior-inferior direction is recommended during PTV generation. The large magnitude of absolute matching differences between Lipiodol and COB, support the use of BWS as a registration surrogate for partial bladder radiation therapy when Lipiodol is contraindicated.

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### 3388

**Application of Nonlinear Least Square Optimization in Solving a Blurring Kernel for a Fluorescent Screen-CCD Dosimetry System**

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**Purpose/Objective(s):** A fluorescent screen-CCD based dosimetry system usually needs post-processing to remove the optical light scatter related blurring. This study aims to solve a kernel for removing such blurring and acquire accurate results by deconvolving it from the measured images.

**Materials/Methods:** Our fluorescent screen-CCD based dosimetry system consists of a fluorescent screen, PMMA phantom blocks and a low dark noise CCD camera and was assembled in an L-shape light-tight box. The fluorescent screen was aligned perpendicularly to the radiation beam line and sandwiched by two 10cm thick PMMA phantom blocks. The fluorescent light was directed to the CCD camera by a 45° mirror below the fluorescent screen. For each captured image, a 3x3 median filter was applied to remove the induced radiation spike noise. Furthermore each image was normalized to its maximum pixel value after a background subtraction. If a blurring kernel was known as k, the measured image M could be expressed as M = I × k, where I was the original image. The problem of solving the kernel k could be transferred to minimize a cost function defined as the difference between a dose distribution T calculated by treatment planning system and I using nonlinear least square optimization, i.e. \( \min_k ||T-I||^2 \). T was calculated from a 10cm×10cm open field at 10cm depth with SAD of 100cm. In the optimization, Wiener filter was used to calculate I for reducing the calculation time. After solving the kernel k, regularized filter was applied to present the final deblurred result for preserving image smoothness.

**Results:** The kernel solved by the optimization method could be fitted by two Gaussian parts and one exponential part. The gamma passing rate for the pre-deconvolved image was 31.7% if a criteria of 3mm DTA and 3% dose difference was chosen. The blurring was significantly reduced by applying the fitted kernel during the deconvolution. The inline and crossline profiles of the deblurred result agreed well with those calculated by TPS and gamma passing rate was 100%. For testing the robustness of the kernel, more plans were created including combination of open fields with different field size, 10cm×10cm open field shaped by MLC, single field with irregular MLC shape, simple one field dynamic MLC plan and two complicated (5 fields) real patient plans. The gamma passing rates for all test plans were larger than 98%.

**Conclusion:** The nonlinear least square optimization method is found to be useful in solving a reliable blurring kernel in a fluorescent screen-CCD based dosimetry system. The fitted kernel is crucial for removing the scattered light in such a system.

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<table>
<thead>
<tr>
<th>Plan Name</th>
<th>Gamma Passing Rate (%)</th>
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<tbody>
<tr>
<td>10x10 Open Field (Shaped by Collimator)</td>
<td>100</td>
</tr>
<tr>
<td>10x10 Open Field (Shaped by MLC)</td>
<td>100</td>
</tr>
<tr>
<td>Open Fields with Different Field Size</td>
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<tr>
<td>Single Field with Irregular MLC Shape</td>
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<tr>
<td>One Field Dynamic MLC Plan</td>
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<tr>
<td>IMRT Plan 1</td>
<td>100</td>
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<tr>
<td>IMRT Plan 2</td>
<td>98.6</td>
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</table>

### 3387

**Dosimetric Impact of a Rectal Spacer and an Increased Near Maximum Target Dose in VMAT Prostate SBRT.55**

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**Purpose/Objective(s):** In 35Gy-in-five-fractions VMAT prostate SBRT, dose coverage of the PTV becomes challenging when the sparing of rectum, bladder, and urethra are strictly pursued. Our current plans assure 33.2Gy to >95%/PTV (V95% ≥95%) only. Looking for an improved V33.2, the dosimetric impact of a slightly increased near maximum target dose (D2%), and of a prostate-rectum hydrogen spacer were tested.

**Materials/Methods:** For eleven patients two VMAT plans, with D2% ≤37.5Gy (Hom) or D2% ≤40.2Gy (Het), on each of two CT studies, before (NoSpc) or after (Spc) transperineal spacer insertion, were computed. All plans assured V95% ≥95%, and less than one cubic centimeter of rectum, bladder, and urethral-PRV (3mm isotropic expansion) receiving ≥33.2Gy (D1cc<35Gy). From the four groups of plans (Hom-NoSpc, Hom-Spc, Het-NoSpc...