Conclusion: Rigid (PLA) and flexible (Ninjaflex) bolus materials provide build-up characteristics within 5% of Solid Water. When incorporated into treatment planning calculations, planned dose for 3D bolus agrees with OSLD measured dose to within 2% on average, and 3D printed bolus gives lower variability in the agreement of the delivered to planned dose. In summary, 3D printed chestwall bolus may be produced in an automated fashion and gives improved consistency of delivered dose accuracy compared to standard sheet bolus.

PO-0942
VMAT planning and treatment preparation process adapted for failure mode and effect analysis
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Purpose or Objective: Mitigating risks in radiotherapy is paramount for patient safety. A volumetric modulated arc therapy (VMAT) adapted to failure mode and effect analysis (FMEA) and implemented through workflow-integrated checklists is presented. This work is in line with efforts done by organizations to integrate a culture of patient safety into radiotherapy processes.

Material and Methods: VMAT is currently being offered to our patients using RapidArc®, Eclipse® 11, Aria-11®, and TrueBeam®; all by Varian Medical Systems (Palo Alto, CA). All systems went clinical in February 2013. Three months into the VMAT program, we realized our operation may be optimized by using the new Workflow feature introduced in Aria® version 11. Consequently, a workgroup consisting of 2 physicists, 3 radiation oncologists, one radiation therapist and one IT was created to identify modes-of-failure in our VMAT planning and preparation process; and to implement a workflow that mitigates their risks. A process-centered risk analysis for VMAT employing FMEA was performed. Risk priority numbers (RPN) for occurrence, severity and detection, were assigned for identified modes of failure based on a simplified model of the AAPM TG100 scoring. FMEA for one task in our VMAT process (Figure 1) is presented as example in Table1. Mitigation actions were implemented into Aria-11® Workflow via integrated checklists where e-signatures are enforced. Risk mitigation strategies employing redundancy, implementation of related policies-and-procedures, documentation, and peer-review were hardwired into the VMAT process.

Results: A VMAT workflow (Figure 1) was designed and included 114 potential-modes-of failure distributed into 4 groups: (1) 59 modes recurring redundantly, (2) 3 decision-type modes forcing re-planning, (3) 33 recurring modes aimed for enhancing communication, and (4) 19 modes occurring only once; some with residual RPN’s necessitating implementation of policies-and-procedures. In the 18 months period leading up to this study, more than 600 VMAT planning and preparation processes were delivered conforming to the workflow in Figure 1. No aberrations in treatments occurred. Shortcomings in e-chart preparations were virtually eliminated.

Conclusion: An adaptation of the VMAT planning and preparation process to FMEA using the Aria-11® workflow was presented. Risk analysis was performed, and risk mitigation was achieved through hardwiring appropriate checklists into the VMAT planning tasks. The adaptation to FMEA resulted in marked improvements in patient safety, process control and process documentation. The presented workflow adaptation to FMEA could serve as a reference or model for clinics offering VMAT.

PO-0943
Dutch national head and neck plan comparison significantly improved treatment planning quality
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Purpose or Objective: The National Platform RT Head and Neck Cancer (HNC, Landelijk Platform Radiotherapie Hoofdhals Tumoren, LPRHHT) is a working party of the Dutch Society of Radiation Oncology, and is engaged in regulating and improving RT for HNC. One of the objectives of the LPRHHT is to evaluate the variation in treatment plan (TP) objectives and possibly improve treatment planning by increased organ at risk (OAR) sparing and reduction of variation between institutes.
Material and Methods: A survey was conducted in all 14 Dutch RT centers treating HNC to identify how a typical TP for oropharynx cancer was generated and judged in terms of PTV coverage, dosimetry requirements and OAR sparing. To this purpose, a CT-scan of an oropharynx cancer patient with delineation of PTVs and OARs was sent to each department. Planning aims were low mean doses of individual salivary glands, swallowing structures and oral cavity with PTVboost/elective coverage V95%-%98. Prescription dose was 70Gy/35 fractions for the boost, 54.25Gy for PTVelective, using a simultaneously integrated boost. Results were presented anonymously, and the 4 centers with lowest OAR doses were asked to share planning tips and tricks with other centers. Centers were asked to undertake a second attempt to lower the OAR dose, using the suggestions of the other centers. In a third step, after evaluating the results, all centers were asked to plan a new case, using their improved planning protocol.

Results: Five different intensity modulated planning systems/techniques were used. Table 1 shows planning aims and averaged plan results. The initial variation in OAR dose was high, with a mean dose range of 20-46 Gy for combined swallowing structures and 18-49 Gy for the submandibular gland. Using the suggestions of best performing departments significantly improved the overall plan quality and reduced the variation in the 2nd phase without loss of PTV coverage. E.g. the submandibular gland mean dose±SD reduced from 35.4±9.3 to 28.0±7.6 Gy. The SD is a measure of variation between institutes. Average combined salivary/swallowing dose±SD decreased from 30.3±5 / 36.6±8Gy to 26.0±3.3 / 29.0±6.3Gy. The more consistent OAR sparing was confirmed by the reduced variations in the plan comparison for the new patient in the 3rd step.

<table>
<thead>
<tr>
<th>Aim</th>
<th>Step 1, mean±SD</th>
<th>Step 2, mean±SD</th>
<th>Step 3, mean±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contralateral parotid</td>
<td>21.8±4.3Gy</td>
<td>18.5±2.5Gy</td>
<td>13.7±2.1Gy</td>
</tr>
<tr>
<td>Combined salivary glands</td>
<td>30.3±5.0Gy</td>
<td>26.0±3.3Gy</td>
<td>24.4±1.6Gy</td>
</tr>
<tr>
<td>Combined swallowing muscles</td>
<td>36.6±8.8Gy</td>
<td>29.0±6.3Gy</td>
<td>29.6±3.9Gy</td>
</tr>
<tr>
<td>PTVboost V95%</td>
<td>95%&gt;98%</td>
<td>98.0±0.7%</td>
<td>98.8±0.6%</td>
</tr>
<tr>
<td>PTVboost V107%</td>
<td>V107%&gt;5%</td>
<td>97.2±3.6%</td>
<td>97.3±1.8%</td>
</tr>
<tr>
<td>PTVelective V95%</td>
<td>95%&gt;98%</td>
<td>97.2±3.6%</td>
<td>97.3±1.8%</td>
</tr>
</tbody>
</table>

Conclusion: Despite many years experience with IMRT for HNC in all centers, treatment plans from all 14 Dutch RT centers showed great variation using the same set of contours. The centers with the highest original OAR doses benefited from the plan evaluation and the tips and tricks from the best performing centers, resulting in significantly lower OAR dose in subsequent optimizations. Such exercise, initiated by a national radiation oncology working party, can significantly improve plan quality and reduce variation between institutes.

PO-0944 Stability in leaf position of 3 generations of optical digitally controlled MultiLeaf Collimators
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Purpose or Objective: To investigate random and systematic uncertainties of MLC-leaf positions for three generations of Elekta MLCs to determine whether highly accurate and precise calibration is possible.

Material and Methods: MLCs of six Elekta accelerators were evaluated; two MLCi, two MLCi2 and two Agility. Details of the heads can be found elsewhere [e.g. Bedford et al. J.A.C.M.P, v14, 2013, pp172]. The precision and accuracy over time of the MLC leaf positions were evaluated using the Electronic Portal Imaging Device, measuring a series of rectangular field with MLC positions moving in steps of 40 mm from -120 mm to 80 mm. Analysis of the images were performed by in-house developed software using steepest gradient analysis and compensating for head rotation inaccuracies.

Random uncertainties were assessed by repeating the above described procedure sequentially five times for each MLC. The random variation was measured as standard deviation of each leaf within a given leaf position, creating a distribution of variances for each MLC. Aggregated random variations for each MLC were calculated as the Root Mean Square of all the individual standard deviations.

Systematic uncertainties or time dependent drift was measured by calculating the average position of the five repeated scans. This average was then subtracted from the similar value measured previously, at the last calibration of the MLC, creating a distribution of shifts between the two time points. The aggregated drift was calculated as the standard deviation of the drift distribution.

Statistical differences of the distributions and differences in median were tested by Kruskal-Wallis tests and differences in the width were assessed by Levenes test.

Results: For all generations of MLC both random and systematic errors are found less than 0.15 mm which is small compared to the EPID pixel size of 0.25 mm and the smallest possible MLC-leaf adjustment of the control systems of 1/12mm (Table and figure). The systematic difference was measured over a time period shown in the table in which no calibrations was performed on the MLC. Both random and systematic errors are statistically significant improved for each generation of MLC (p<0.001).

For the latest generation, the Agility, the development has resulted in a random error of 0.03 mm. The systematic error for Agility was found to be 0.07 mm when evaluated more than 79 days after calibration.

All measurements are made relative to radiation iso-centre, thus the group median drift (table and figure) is a combination of stability of MLC and radiation iso-centre. The small values in group median reflect high stability of both radiation iso-centre as well as MLC.