[OA034] Error detection sensitivity of a commercially available system for 3D plan verifications
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Purpose. The complexity of the treatment techniques IMRT (Intensity Modulated Radiation Therapy) and VMAT (Volumetric Modulated Arc Therapy) introduced the requirement of an individual plan verification. The latest development is 3D verification which allows evaluation in terms of 3D gamma values but also a judgment based on differences in dose distributions on individual patient CT data and in dose volume histograms. For a verification tool the error detection sensitivity is important. The purpose of this work is to evaluate the accuracy and the sensitivity of the gamma evaluation of the 3D verification software MobiusFx when a systematic error in one parameter is applied. The results are compared to an established 2D-measurement based method.

Methods. 11 IMRT and 11 VMAT plans were selected as reference plans. For every reference plan a systematic offset of 1 mm, 2 mm and 3 mm in the same direction was applied to the Multi-Leaf-Collimator (MLC) positions. All plans were irradiated and verified simultaneously with MobiusFx and MatriXX Evolution 2D array measurement. For both verification systems the applied dose distributions were evaluated using the gamma method based on the reference plans. In MobiusFx additionally the MLC position errors were evaluated.

Results. Regarding the gamma evaluation results, MobiusFx and MatriXX Evolution 2D measurements have almost the same sensitivity: The gamma evaluation of both systems detected shifts of 1 mm in VMAT plans and shifts of 2 mm and larger in IMRT plans. The information of the MLC position error provided by MobiusFx allows further to detect errors down to a shift of 1 mm in IMRT plans, giving an advantage over the MatriXX measurement.

Conclusions. MobiusFx shows a high error detection sensitivity, comparable to MatriXX Evolution. Through the gamma calculation and the MLC position error it is possible to detect errors down to a shift in MLC positions of 1 mm. It is recommended to inspect all the above parameters during plan verification.

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[OA035] Implementation of RapidPlan for head and neck cancer patients: The dosimetric advantages
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Purpose. To evaluate a RapidPlan (RP) knowledge-based planning model, generated for advanced head and neck cancer (HNC) patients.

Methods. Dosimetric and geometric data from 75 HNC patients were selected for model training. Volumetric modulated arc therapy using three arcs were used for all plans. Four different dose regimes, with either two or three dose levels, were combined in the model (60 Gy, 50 Gy in 30 fractions, 66 Gy, 60 Gy, 50 Gy in 34 fractions, 68 Gy, 60 Gy, 50 Gy in 33 fractions, and 76 Gy, 66 Gy, 56 Gy in 56 fractions). DVH estimates were generated for all organs at risk (OAR) and the order of their associated priorities followed national guidelines. The model was validated on 20 HNC patients, all with prescribed high dose levels of 66 Gy. For each patient a clinical and a RP plan were individually optimized based on either the clinical template or the RP DVH suggestions, respectively. The two plans were compared according to target dose coverage and mean doses to the brainstem, salivary glands, oral cavity, lips, thyroid, and swallowing structures.

Results. Target coverages were very similar for both planning strategies. For the planning target volumes receiving 95% of the prescribed doses, the average changes between the clinical plans and RP plans, were −0.07 ± 0.4%p, 0.11 ± 0.5%p, and −0.08 ± 0.4%p, respectively. Mean doses to all OARs were unchanged except for the thyroid, the pharyngeal constrictors and the glottis larynx, where a significant improvement was observed. The median mean doses were reduced by 0.5 Gy (p = 0.048), 1.0 Gy (p = 0.027), 3.8 Gy (p = 0.0001), 2.9 Gy (p = 0.0003) and 3.9 Gy (p = 0.0013), respectively. Furthermore for 25% of the patients the mean dose to the glottis larynx, the middle and the lower pharyngeal constrictor are lowered by at least 8.9 Gy, 6.3 Gy and 5.2 Gy, respectively.

Conclusions. Using RP for knowledge-based planning of HNC patients significantly improves the mean doses received by a number of OAR, without changing the mean doses received by the remaining OAR and without deteriorating the target coverage.

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[OA036] Clinical implementation and evaluation of the Mobius3D system for independent dose calculation
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Purpose. The complexity of dose planning and treatment delivery systems has increased and necessitates a more comprehensive physics quality assurance (QA). These QA checks can, however, be quite time consuming. Therefore, there is a need for automation of QA which usually rely on empirically established tolerance levels. Mobius3D is a commercial fully automated QA system that uses a collapsed cone convolution/superposition algorithm for verification of treatment plans. The purpose of this study was to investigate the level of deviation between this system and the clinical commissioned treatment planning system (Eclipse v.13.5) using the Anisotropic Analytical Algorithm when the MLC modeling was optimized.

Methods. The Mobius3D system comes with golden beam data and calculates the dose on the patient CT data set. For MLC optimization, 8 IMRT/VMAT plans from various anatomical regions were included and recalculated in a cylindrical plastic phantom containing two planar diode arrays (Delta4 phantom, ScandiDos). The plans were then verified experimentally at the accelerator and all passed a local 3%/2 mm gamma criteria (passing rate > 90%). The dosimetric leaf gap (DLG) used to model the MLC in Mobius3D was optimized to keep the PTV mean dose of the 8 plans within 2% in the Delta4 geometry resulting in a +0.6 mm adjustment of the DLG from the default value. To establish the level of dose deviation and establish acceptance criteria, 34 treatment plans in different geometries, such us lung (10), head and neck (HN, 10), and pelvis (14) were evaluated for both IMRT and VMAT.

Results. The absolute mean and max PTV dose deviation for (lung/ HN/pelvis) were: 0.8/2.2/2.1% and 1.4/2.9/2.8%. All max deviations were positive, i.e. a higher dose estimate by Mobius3D.
plans before DLG adjustment all showed negative deviations of −3.12/−3.8% (PTV mean/max).

Conclusions. A random sample of treatment plans were within 2.5% in absolute mean dose of the PTV between Mobius3D and the TPS. MLC parameter optimization plays an important role in establishing an acceptance criterion.

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[OA037] Advanced dose calculation algorithms in lung cancer radiotherapy: Implications when treating in deep inspiration breath hold

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Purpose. Modern dose calculation algorithms model absence of lateral charged particle equilibrium to a limited extent. The resulting dose calculation uncertainties are most noticeable in strongly heterogeneous regions, like the thorax, and will increase in deep inspiration breath hold (DIBH) due to decreased lung tissue density.

Methods. For 17 stage I and 17 stage III lung cancer patients, a plan in free breathing (FB, based on midventilation) and in DIBH were generated with Anisotropic Analytical Algorithm (AAA). Stage I disease was treated with 3D-conformal stereotactic radiotherapy (SBRT), 45 Gy in 3 fractions, prescribed to 95% isodose covering 95% of PTV and aiming for 140% dose centrally in the tumour. Stage III disease was treated with volumetric modulated arc therapy (VMAT), 66 Gy in 33 fractions, prescribed to mean PTV dose. Calculation grid size was 1 mm for stage I and 2.5 mm for stage III. All plans were recalculated with AcurosXB with same MU as in AAA, for comparison on target coverage and dose to risk organs.

Results. Lung volume increase in DIBH resulted in % decreased lung density for stage I (from median −757 HU to −811 HU) and 12% for stage III (from median −723 HU to −822 HU). In stage I, AAA overestimated all PTV parameters (p-values <0.01) compared to AcurosXB, with largest impact in DIBH. Mean dose and D98% were overestimated by 2.0/2.3 Gy in FB and 3.1/4.0 Gy in DIBH. These clinically relevant differences may be a combination of small targets and large dose gradients in the SBRT treated volume. In stage III, AAA systemically overestimated the target coverage compared to AcurosXB. D98% was overestimated by median 1.1/1.2 Gy in CTV and 1.5/2.1 Gy in PTV, in FB and DIBH respectively (p < 0.01). Hot spots (estimated as D2%) did not differ between AAA and from AcurosXB, in both FB and DIBH. No significant difference was observed for lung and heart dose parameters between the algorithms, for both FB and DIBH, in the two patient cohorts.

Conclusions. Choice of calculation algorithm impacts the calculated dose distribution in the target. AAA overestimated target coverage compared to AcurosXB, especially in DIBH for stage I lung cancer treated stereotactically.

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[OA038] Does automation reduce the number of errors in quality control of treatment plans for external beam radiotherapy?

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Purpose. Any single treatment plan error should be detected and corrected prior to treatment either during a check procedure or by built-in safety features of the treatment planning (TPS) or record and verify systems. However, as delivery techniques have become increasingly complex the number of possible errors in a plan has increased dramatically. It is therefore desirable to automate as many check procedures as possible to eliminate manual errors. In this work we investigate the effect on error rates of introducing automation in quality control of patient treatment plans.

Methods. Dose constraints, fractionation and best practice guidelines for all treatment schemes in our clinic taken from relevant guidelines (institutional, national, international or clinical trial) were collected in a database. A TPS script was written to generate a report comparing plan information with reference values from the database as pass/fail criteria. To determine if automation reduces the number of errors compared to manual quality control, 322 consecutive plans approved for treatment with manual quality control between September 1st and October 1st 2017 were retrospectively subjected to automated quality control with the script. All errors were recorded and severity was scored using the recommendations from the AAPM TG-100 report.

Results. 320 errors were detected in 10,243 individual checks (3.1%). Three errors were found to have had impact on target dose, ranging from 0.5% (severity 5) to 7% (severity 7), while another 18 could have caused either geographic or dosimetric impact (severity 5+). The remaining 299 errors were either purely clerical or could at worst cause minor inconvenience to staff, severity score 1–2.

Conclusions. Automation of treatment plan quality control reduces error rates and increases adherence to guidelines compared to a purely manual workflow.

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[OA039] Contouring and dose reporting for lower urinary tract sub-structures in cervix cancer

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Purpose. Radiotherapy related bladder morbidity include various clinical endpoints (i.e. frequency, cystitis, incontinence, bleeding, fistula) that may be related to various anatomical sub-structures.