Values around 100HU were obtained for the PLA, and 780HU for the silicone from the phantom CT scan. The differences between the dose calculated with the TPS and measured with ionization chamber were analyzed. Plan doses shown differences below 1.5% in all cases. Analysing the fields individually, the biggest difference was 3.6 % and the average difference was 0.68±1.54%.

Conclusion

We can conclude that it is feasible to design and construct a 3D printed heterogeneous phantom representing patient anatomy. This phantom can be routinely used to perform dosimetric checks of advance external beam treatment modalities.

EP-1841 DVH based patient QA in SRS/SRT/SBRT using a new transmission detector.

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Purpose or Objective

Dolphin's new transmission detector and compass DVH-based analysis program to validate stereotactic plans.

Material and Methods

20 lung SBRT and 25 SRS/SRT patients were prepared non-coplanar VMAT field plans in the Monaco 5.11 treatment planning system. Patient QA was measured with the Dolphin trasmission detector and evaluated by gamma index analysis in the DVH based Compass 4.0.27 program. In stereotactic plans, treatment is performed with a heterogeneous dose distribution in the target volume and plans with a high dose gradient outside the target. Gamma index values were calculated according to the criteria of 3%-3mm, 2%-2mm, 1%-1mm and 3%-1mm as dose difference and distance to agreement in QA of stereotactic plans. The gamma value of >90% of all points evaluated in two dimensions is not sufficient to detect plan accuracy in stereotactic treatments. For a more detailed analysis, average gamma index values were calculated, which was calculated by taking the numerical values of the gamma values at each evaluated point into account.

In stereotactic plans there is a rapid dose drop with the high dose gradient outside the target. For this reason, the target volumes were given 1cm, 2cm, 3cm and 4cm margins, and the regions to be analyzed in three dimensions were formed. The average gamma index values of these regions were calculated.

Results

The plans were calculated by Monte Carlo dose calculation algorithm in Monaco planning system. Then the plans transferred to the compass system were recalculated with the Collapse Cone algorithm. Finally, the dose obtained with the Dolphin detector was transferred to the computed tomography images and computed with the collapse cone algorithm. Differences between TPS and Dolphin in SRS/SRT plans, PTV1; 5.1%, PTVaverage; 8.1% and PTV99; 9.2%. Differences between Compass and Dolphin in SRS/SRT plans, PTV1; 2.9%, PTVaverage; 4.8% and PTV99; 6.5%. Differences between TPS and Dolphin in lung SBRT plans, PTV1; 3.5%, PTVaverage; 2.2% and PTV99; 2.6%. Differences between Compass and Dolphin in SRS/SRT plans, PTV1; 2.7%, PTVaverage; 2% and PTV99; 2.6%.

When average gamma values are examined in the regions formed with 1,2,3,4 cm margins in SRS/SRT/SBRT plans; 3%-3mm 0.34-0.52, 2%-2mm 0.51-0.75, 1%-1mm 0.92-1.14, 3%-1mm 0.36-0.81. The most accurate criteria for SRS/SRT/SBRT is 2%-2mm and 3%-1mm. In 2D gamma analysis, SRS/SRT was 96% and SBRT was 88% according to the criteria of %2-2mm. SRS/SRT was 93% and SBRT was 83% according to the criteria of %3-1mm.

Conclusion

DVH-based analysis is very important in verifying stereotactic plans. it is more accurate to analyze according to the criteria of 3-1mm and 2-2mm because it has high homogeneity and gradient index in stereotactic plans.We do a more comprehensive analysis with average gamma.

The main reason for differences between Monaco and Compass with dolphin measurement is that the plans have high dose gradients and high dose heterogeneity. Especially in small volume PTVs these differences are increasing.

EP-1842 Benchmarking of Monte Carlo dose calculation for MLC based CyberKnife Radiotherapy

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Purpose or Objective

Vendor-independent Monte Carlo (MC) dose calculation (IDC) for patient-specific quality assurance of multi-leaf collimator (MLC) based CyberKnife treatments was recently developed. This IDC framework is now used to benchmark and validate the new vendor-developed MC dose calculation engine for MLC based treatments built into the CyberKnife treatment planning system (TPS MC).

Material and Methods

Both the IDC framework and TPS MC algorithm are commissioned using output factor, dose profile and depth dose (IDC commissioning) and tissue-phantom ratio (TPR) (TPS MC commissioning) measurements of the same CyberKnife M6 system. The IDC framework uses the EGSnrc MC transport, EGS++ geometry package and DOSXYZnrc scoring code, while the TPS MC uses a proprietary system. For photon transport in TPS MC, CT numbers are converted to either air, soft tissue or bone composition with mass density assigned from a CT calibration curve included in plan data. Electron and positron transport in TPS MC is performed with pre-simulated tracks in water. In IDC, CT numbers are converted to 14 different biological material compositions and mass density according to a built-in CT calibration curve. The benchmark includes dose profiles in water in 15 mm depth and depth dose curves of 11 rectangular MLC shaped fields ranging from 7.6 mm x 7.6 mm to 115.0 mm x 100.1 mm, which are compared between IDC, TPS MC and measurements in terms of dose difference (DD) and distance to agreement (DTA). Dose distributions of nine clinical cases (7 lung and 2 prostate) are calculated using both the IDC framework and the TPS MC from CT, plan and structure data. Quantitative comparison of these dose distributions is performed using dose-volume parameters and 3D gamma analysis with 2% global DD and 1 mm distance criteria and a global 10% dose threshold. Dose distributions in the TPS MC are calculated with a targeted uncertainty of 1% for prostate and 2% for lung cases and smoothed with a Gaussian kernel. All IDC dose distributions show mean statistical uncertainties in voxels with dose higher than 50% of the dose maximum of 0.6% – 1.3% for all treatment plans.

Results

Dose profiles in 15 mm depth show agreement between TPS MC and IDC to be within about 3% / 1 mm with the largest differences found in the shoulder region of the two largest field sizes, where the TPS MC calculates higher doses than IDC. Depth dose curves agree within 2.3% / 1 mm with the largest difference found for the smallest MLC field size (7.6 mm x 7.7 mm), where IDC calculates lower doses than both measurement and the TPS. For the nine clinical treatment plans, mean PTV doses differ by an absolute mean of 0.7% between TPS MC and IDC (range -1.0% to +2.3%). Lung V20 agrees within +/- 1.5% for the lung cases. Gamma passing rates are >=97.2% for all cases.

Conclusion

TPS MC was successfully benchmarked against an independent MC dose calculation framework.

EP-1843 Pre-verification of SBRT plans using VMAT with 6FFF beams - quantitative and qualitative analysis

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Purpose or Objective

The SBRT of patients with lung tumor using respiratory-gated VMAT is an advanced procedure requiring careful dose verification. For small fields with MLC HD, FFF beams which were used with present of tissues heterogeneous in lungs and doses which reach up to several greys the verification has become a challenge. Commonly used gamma method with standard (3%/3mm) criteria could be insufficient. In addition to quantitative analysis, an advanced qualitative analysis of the comparative dose distribution is required.

The aim of the work was to determine the optimum verification conditions for respiratory-gated SBRT using VMAT with 6FFF beams and evaluate the usefulness of DVH reconstructed based on measurement (DVH-measured).

Material and Methods

In the first part, the correctness of 3D dose reconstruction and DVH-measured (Verisoft 7.1 PTW, Freiburg) based on measurement with SRS1000 and rotational Octavius phantom was checked for 6FFF VMAT (TrueBeam 2.5 with MLC HD) and different open field size (2x2-12x12cm2), gantry angle (0, 90, 270, 180), open arc field. Next, the measurement and analysis with gamma method (DD: G/L3%/2%, DTA: 3mm/2mm with different threshold: 5, 50, 90%) were used to verify selected 10 treatment plans. In addition, using DVHs reconstructed based on measurement in comparison to planned DVH, individual plans were analyzed for PTV structure (D98, D50, D2). All plans were also analysed with Quazar motion phantom.

Results

For open fields, for different angles of gantry and arcs, compliance with the planned values at the gamma level (L2%/2mm) of 99.1-100% (SRS) was achieved. For field sizes less than 5x5cm, the coefficient due to small fields was determined to achieve score results: 97.4-99.5%. For phantom with artificial structures, the agreement of the DVH-measured parameter with DVH-planned values less than 1.5% was obtained. For patients, mean score values using gamma evaluation method were achieved, (5, 50, 90% of TH), respectively: 97.99±0.88%, 94.02±3.53%, 79.72±14.31% (L2%/2mm), 99.75±0.27%, 98.79±1.44%, 92.68±6.87% (G3%/3mm). The differences between DVH-measured for clinical cases and DVH-planned were as below, in median: -0.98% (D98), 1.89% (D50), 8.73% (D98).

Conclusion

The 3D dose reconstruction and DVH-measured with a high resolution SRS1000 after appropriate adaptation and validation is suitable for pre-verification of SBRT. The gamma method is a well-known method, but in advanced techniques more rigorous criteria (L2%/ 2mm) also with various threshold should be applied. DVH-measured with presentation of failed points on patients' CT scans can be used as an additional (qualitative analysis) tool to identify clinically-relevant errors.

EP-1844 A dosimetric comparison of 3 types of breast treatment plans. 3D conformal, RapidArc and IMRT

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Purpose or Objective

RapidArc is a fairly new technique in radiation therapy delivery. In spite of this, it is widely used for almost every type of tumor and location. The need of use of intensity modulated radiation therapy with static fields or arc is not always justified for all the treatment sites. We decided to provide a dosimetrical analysis for the 3 types of treatment plans that we mentioned earlier. The purpose is to give clear guidelines for breast radiation therapy in selecting the optimal beam placement and type of plan.

Material and Methods

We chose 25 patients with treatments delivered to the left breast, supraclavicular area, and axilla, all treated concomitant. The patient selection was not restricted by what type of treatment plan was initially developed. If the patient was treated with a 3D conformal plan we generated the other type of plans trying to obtain the same coverage or better and the same healthy tissue sparing or better as the initial plan. We then analyzed the dose uniformity, the hot spots in the normal tissue and the maximum dose in the planning target volume (PTV). Multiple arc placements and length have been used as well as multiple beam placement were used for RapidArc and IMRT respectively to obtain the best dosimetric coverage of the tumor and the best normal tissue sparing. The volumes that received 5% dose (V5), V10 and the mean dose (Dmean) for the ipsilateral lung and contralteral lungs were evaluated for the 3 methods of planning. Tumor control probability (TCP) and normal tumor complications probability (NTCP) were evaluated as well for all 3 methods.

Results

Our results do not indicate a superiority of the RapidArc over the IMRT. In many cases IMRT can be superior to the 3D plans but not by a significant difference. We noticed that the TCP and NTCP do not indicate an improvement when using RapidArc versus IMRT.

Conclusion

Although RapidArc is a method of treatment that shortens the treatment time, therefore minimizes the time a patient spends on the table, we do not see a clear advantage of using the arc therapy when treating breast with radiation therapy. Yes we minimize the uncertainties generated during treatment by possible patient movement but the benefits do not exist. On the contrary all the treatment plans generated with static IMRT are dosimetrically superior to RapidArc. In some cases even a 3D plan is superior to an IMRT plan therefore superior to arc therapy.

EP-1845 Dosimetric verification of Leksell Gamma Knife plans under the presence of inhomogeneities

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Purpose or Objective

Leksell Gamma Knife plans can often be calculated without heterogeneity corrections. The purpose of this study is to evaluate the impact on the dose in zones close to existent heterogeneities inside the intracranial area, comparing experimental results with the calculated dose by the planning system, in order to estimate the uncertainties to be expected on the delivered dose distributions under different scenarios.

Material and Methods

A LUCY 3D QA phantom was used for this study. This was adapted to fit air cavities, bone and metal inserts inside its spherical volume. Radiochromic films and