this study is to report the measured body exposures treated with single dose intra-operative electron radiation therapy (IOERT) in a large cohort of patients and to analyze which beam parameters impact the body exposure.

Materials and Methods: During an almost 5-year period, more than 500 Partial Breast Irradiation (PBI) procedures have been performed with IOERT in our institution for pT1N0 unicentric ductal breast carcinoma. A dose of 21 Gy was prescribed at the 90% isodose depth. Beam delivery was achieved with a Mobetron 1000 (Intraop, Sunnyvale, Ca). This mobile accelerator produces 4, 6, 9 and 12 MeV electron Beams with a 10Gy/min dose rate. Although the Mobetron is self-shielded device, a small component of straight X-rays radiation is always present during treatment delivery. In order to measure their body exposure coming from this straight radiation, three LiF Thermo-Luminescent Dosimeters (TLD) were positioned on each patient, respectively on the thyroid, on the contralateral breast and at the gonads level. The TLD were placed in an Aluminum container thick enough to provide electronic equilibrium and to stop any scattered electrons. TLDs were directly read just after PBI in a manual Harshaw reader under Nitrogen flow.

As a comparison, the body exposure in a series of 30 BCT patients treated with 6 MV external beams was measured in the same way.

Results: Mean doses for PBI treatments on the thyroid, contralateral breast and gonads were 0.82, 0.41 and 0.14 cGy respectively. Higher energy beam gives significant higher body exposure. The field size, ranging from 35 mm to 65 mm does not influence the body exposure. On the other hand, the treated quadrant has an impact on measured doses. Patients treated with external radiation received much higher body doses, from 25 times to more than 100 times higher for the contralateral breast.

Conclusions: As radiation protection is concerned, IOERT is a safe procedure and gives very small body doses, unlikely to increase the carcinogenetic risk significantly, especially in the contralateral breast. Pregnant women might, in certain circumstances and with additional safety measures, be treated with the IOERT approach with an acceptable fetal dose.

OC-0568

Necessity of using an image modality to improve IORT dosimetry

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Purpose/Objective: To evaluate the necessity of using an image modality in order to improve and adapt the IORT dosimetry based on Monte Carlo simulations.

Materials and Methods: A model of the Intrabeam™ system has been previously developed with the GATE platform taking into account the different parts of the device. This study was performed on 25 patients. A preoperative CT acquisition of the patient breast was performed and included in the simulation allowing accurate dose calculation (Figure 1).

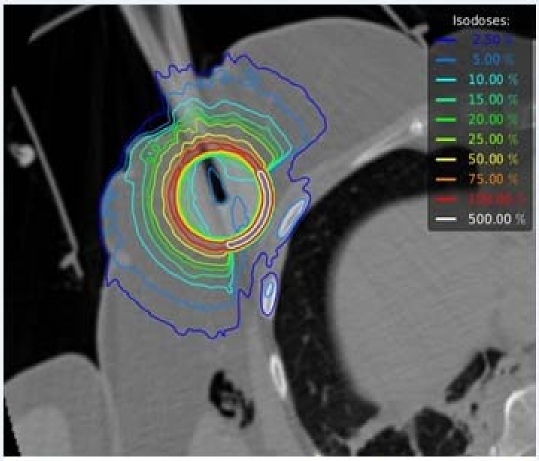

Figure 1: Dose distribution simulated on MC accounting for patient tissues heterogeneities.

During IORT, in vivo dosimetry was performed on 15 patients using thermoluminescent dosimeters (TLD) placed on the skin at 1 and 3 cm around the spherical applicator. First, comparison between simulation results on GATE and TLD measurements have been performed to confirm the dose prediction at the TLD locations. The dose simulated was recorded at the same initial position of the TLD. The depth dose curves between MC simulations and software computed doses have been compared. Then, the dosimetric influence of the applicator's position was simulated: the applicator has been moved from 5 mm to 10 mm around its initial position. Finally, in addition to pre-operative CT acquisition, an intraoperative CT has been acquired on three patients in order to validate the overall dosimetric evaluation protocol.

Results: Patient results showed a good agreement between clinical experiments and simulations. Indeed the relative mean deviation between TLD and GATE dose measurements was 0.1% ± 0.11% with a maximum of 0.33%. The simulation uncertainty was less than 1% (from 0.41% to 0.95%). Breast densities significantly changed the depth dose curves compared to the one given by the Intrabeam software which consider the breast as homogeneous. Considering the applicator displacement, the mean percentage deviation of the dose was 6.3% ±44.9%, 8.8% ±89% at 5 mm and 10 mm respectively. These results indicated that the dosimetry was greatly influenced when moving the applicator position due to the high dose fall-off of the low energy x-ray source.

Conclusions: We proposed the use of an accurate model of the Intrabeam system on the GATE platform accounting for the tissues heterogeneities. Using a pre-surgery image modality could greatly optimize the dosimetry by determining a better applicator position. The dosimetric evaluation of the proposed platform with patient datasets supports its use for patient specific dosimetry planning. By this way we should be able to adapt a personalized dosimetry and not also prescribe the same dose to all the patients.

OC-0569

Optimized Monte-Carlo intra-operative radiotherapy dose prediction for flat and surface applicators

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Purpose/Objective: Intra-Operative Radiation Therapy with low energy X-rays (XIORT) is largely used for breast cancer treatment with spherical applicators [1]. However, only a few centers are involved in superficial intraoperative radiotherapy [2] and little information is available about the dose distributions of the INTRABEAM® (Carl Zeiss) obtained with these dedicated applicators. This study proposes a fast and precise method to calculate dose distribution from Monte-Carlo phase space data in the case of flat and surface applicators.

Materials and Methods: We developed a strategy to determine realistic Phase Space Files (PSF) that reproduces the experimental dose distributions. On one hand, monoenergetic PSF and corresponding depth-dose profiles (PDD) are generated only once with a full Monte-Carlo simulation using with the penEasy [3] code, one for each energy up to 50 keV (computing time of a few CPU-days). These simulations include a detailed geometry of the device which describes the general features of the experimental dose of standard flat and surface applicators. These monochromatic PSF are binned and parameterized in terms of the relevant variables to make them easy to manipulate. On the other hand, we take the energy spectrum as a fitting function which is optimized by means of a genetic algorithm [4] to describe the experimental PDD of any applicator. Finally, the binned precomputed monoenergetic phase space files and the fitted energy spectrum are combined to build the actual PSF optimized to describe the dose distribution of the considered applicator. From the final optimized phase space file, the dose is computed either by penEasy or by an in-house analytical algorithm which takes into account condensed history simulations of both photoelectric and Compton interactions for X-rays up to 50 keV. We compared the computed dose distributions with measurements first in water, then in homogeneous and heterogeneous media (lung, bone, air).

Results: Building the fitted PSF only takes a few minutes in a single core (i7@2.5 GHz). Dose distributions computed with the proposed strategy from the optimized PSF are in good agreement with the measurements performed at the Institut Universitaire du Cancer (Toulouse, France) with the flat and surface applicators.

Conclusions: The dose calculation process presented in this work is fast, flexible and optimized to simple experimental data. This method is being implemented into Radiance® (GMV SA, Spain), a powerful IORT Treatment Planning System [5], for all INTRABEAM (Carl Zeiss) applicators and can be used for a wide range of clinical indications.

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OC-0570

Which boost is the best boost? a comparison of BCT ìboostî techniques

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Purpose/Objective: Breast Conservation Therapy (BCT) is the 'gold standard' in early-stage breast cancer treatment. Many BCT patients also require a boost to the tumor bed in addition to 3 to 5 weeks of external beam radiation treatment (EBRT). There are several different technologies that can be used to boost the tumor bed. This study reviews these various technologies, compares the volumes irradiated, the dose distributions to the tumor bed, and the overall homogeneity of the treatment, as well as the dose which is delivered to critical structures. The advantages and disadvantages of each boost approach are discussed.

Materials and Methods: To simplify comparison in this study, we selected patients to evaluate who had a maximum tumor dimension of 2 cm at the time of the surgery. We selected patients with left-breasted tumors to maximize the impact of each technique on treating critical structures. For patients treated totally with EBRT, we selected patients who started EBRT no later than 6 weeks post-surgery. Both 3 and 5 week EBRT treatment schedules were studied. The TPS system and home-made software evaluated the dose distributions of the combined EBRT boost and EBRT whole breast treatment. For patients treated with IORT, the dose map was added to the EBRT distribution with a suitable registration. Estimated RBE corrections were made for the 50 kV devices. The α/β model was used to convert IORT doses to normal fractionated EBRT doses.

Results: Three (3) patients treated with each technique were studied and the results were averaged to obtain the final data for each technique. Dose to critical structures were compared for all techniques knowing that the driving factor for dose to critical structures is the EBRT dose, not the boost dose. In theory, IORT with electrons had the most uniform dose over the smallest boost volume of all boost techniques but several parameters can influence the boost volume (50 KV applicator diameter, presence of a chest wall shield, etc...)

Conclusions: There are significant variations in the volumes and dose homogeneity of the irradiated boost volumes depending on which boost technique is used, but this does not appear to significantly impact the overall physical dose distributions when the EBRT dose is added to the boost. BED variations are somehow greater. There are, however, significant differences in advantages in one technique over another, and these can result in both cosmetic and oncologic differences.

Poster Discussion: Innovation in physics and technique of IORT

PD-0571

New genetic algorithm-based procedure to determine phase space for intraoperative radiation therapy

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