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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 iboostî 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/ß 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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Purpose/Objective: Phase space files (PHSP) generation is a time consuming procedure and further the size of PHSP make them difficult to work with. We present a procedure to generate within a few minutes a PHSP which reproduces the experimental PDD, by optimizing the energy spectrum that fits the experimental dose data with a genetic algorithm [1], and using the information from a previously stored full database of monochromatic PHSP and percentage depth dose (PDD) from a specific simulated accelerator.

Materials and Methods: Mobile and linear accelerators used in intraoperative electron radiotherapy (IOERT), such as LIAC, NOVAC 7 and VARIAN 21EX, have been simulated in detail with penEasy [2]. A full set of monochromatic PHSP, covering the accelerators energy spectrum range from 1 MeV to 14 MeV, have been calculated and stored (100 million histories, 48 hours running time on a 8 cores high capacity cluster). Each PHSP is binned in the type of particle, energy, axial angle and radial position. PDD in water is obtained with these parameterized PHSP with DPM [3] and stored as well (1 hour computation time on a 8 cores high capacity cluster). These calculations, both the PHSP and the PDD simulations for the monochromatic PHSP, need to be done only once. After that, our procedure consists of two consecutive phases. In phase one, by means of a genetic algorithm, an optimized energy spectrum which weights the relative contributions of the monochromatic PDD that reproduces the experimental dose data is generated. In phase two, the previously simulated PHSP are weighted by this energy spectrum to obtain the resulting PHSP that fits the experimental measurements. These two phases have to be performed for each individual case, taking a few minutes computation time in a single core (i7@2.5 GHz) PC.

Results: The genetic algorithm performs an accurate fitting of the monochromatic PDD to the experimental data. Dose calculated from the resulting weighted PHSP are in good agreement with the measurements for all the accelerators studied, not only the PDD but also transverse dose profiles (figure 1). Computation time is below 3 minutes in a single core PC.

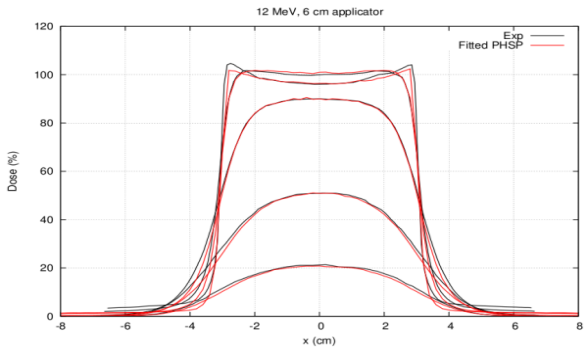

Figure 1. Transverse dose profiles in water

Conclusions: Preliminary results show that the genetic algorithm-based method to determine PHSP from a experimental PDD in water reproduces dose distributions measured with different accelerators, accurately enough for IOERT planning. The method is flexible and fast, being able to obtain a PHSP for any accelerator within minutes. The genetic program and the PHSP weighting algorithms have been incorporated in Radiance® [4], a treatment planning system for intraoperative radiation therapy developed by the GMV company.

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PD-0572

In vivo dosimetry using Gafchromic films during IOERT of rectal cancer

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Purpose/Objective: Radiochromic films and MOSFETs have been used successfully for in vivo measurements during intra-operative electron radiation therapy (IOERT) of breast cancer[1]. At our institution, surgery of locally advanced and/or recurrent rectal cancer is often complemented with IOERT. The aim of this study was to determine the actual dose delivered during IOERT of rectal cancer through in vivo measurements using Gafchromic EBT3 films.

Materials and Methods: In vivo measurements were performed during IOERT treatments in 21 patients with advanced or recurrent rectal cancer. Treatments were performed with a Varian Clinac 2100 CD conventional linear accelerator, adapted for IOERT with a hard docking system of cylindrical applicators (5 to 10 cm diameter) and bevel angles of 0, 15, 30 and 45°.

A small piece of Gafchromic film (1.5 x 1.5 cm^2) wrapped in a sterile plastic envelope was placed by the radio-oncologist on the irradiation surface. Film position was documented by a photo taken before the irradiation. The films were digitized and the pixel values converted to dose using a previously obtained calibration curve. Results were analysed using ImageJ and Octave.

Results: Good agreement between measured and expected values (diff. ≤ 7%) was obtained when irradiation surfaces were nearly flat and the film was positioned near the centre of the applicator (9 procedures).

The other results were analysed individually, based on irradiation conditions, the surface geometry and the position of the film relative to the applicator. Concave or irregular irradiation surfaces are frequent in pelvic IOERT. Haematic fluid build up also occurs and bevelled applicators are frequently used. This leads to much more complicated irradiation geometries than for breast IOERT. Dose differences between 3% and 10% were observed within a single piece of Gafchromic film, depending on the irradiation conditions (Figure 1). This 2D dose distribution yields valuable information, and constitutes one advantages of using film instead of point detectors such as MOSFETs.

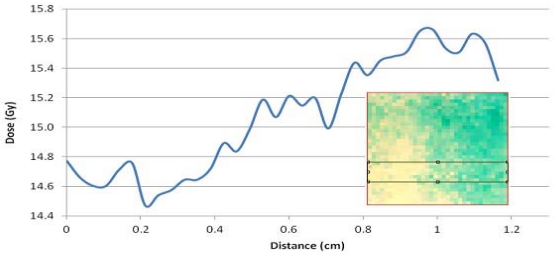

Figure 1. Mean dose distribution along a defined region of interest on the Gafchromic film

Conclusions: These preliminary results confirm that in vivo dosimetry during pelvic IOERT is possible, and potentially