RADIOThERAPY PLANNING SYSTEM FOR IORT

TECHNOLOGICAL INNOVATION FOR INTRAOPERATIVE RADIATION THERAPY PLANNING

radiance, the Intraoperative Radiation Therapy (IORT) planning system, improves the safety of IORT procedures by means of a pre-, intra- and post simulation of the treatment. In this simulation, it is possible to alter the different parameters of the procedure to evaluate the outcome without stress in the treatment decision-making process.

The system has been developed by a top-level GMV-led multidisciplinary team, with the participation of the Gregorio Marañón University Hospital and an extensive list of Hospitals with large experience in IORT as well as University groups and companies with deep background in radiotherapy technologies.
SECTION 1
INTRODUCTION

Radiotherapy (RT) involves the use of ionizing radiation for the treatment of malignant illnesses. The medical specialty that uses ionizing radiation for the treatment of illnesses is RADIATION ONCOLOGY (RO). It is a clinical specialty devoted to the diagnostic aspects, clinical care and therapy oriented to the use of radiation treatments as well as the assessment of alternative or related treatments [Palacios 2002].

Its main characteristic is the technical complexity of its procedures, the costly investment in equipment as well as its specific legal regulations that cover not only the products quality control but also the radioprotection to the patients and staff in the welfare units. Oncology, Radiobiology and Radiophysics are the knowledge areas that lay the scientific foundations of RT [Palacios 2002, González 2005].

The goal of RT is the irradiation of tumoral areas or anatomical areas of interest (risk of relapse areas) avoiding, as possible, affecting critical organs. The choice of the volume of irradiation, the total dose for the tumor, as well as the division or the use of other concomitant treatments is the basis for planning the RT. The need to adapt the irradiation not only to the tumoral volume but also to the anatomy of each patient make the use of CT, NMR and/or PET/CT images indispensable for RT, as they allow to take anatomical references and delimit the area for irradiation [Calvo 1998, Nieto 1999].

Together with the raise of state-of-the-art linear accelerators and the possibility of adding instruments - such as multi-sheet collimators, special applicators for intraoperative and stereotactic RT, tomographies in Tomotherapy or Intensity-Modulated Radiation Therapy (IMRT) – the possibilities of giving a more accurate and less toxic radiation have increased, that is, therapeutic benefits have been achieved.

The development of computer systems, the advance in Radiobiology, a better knowledge on the mechanisms involved in cell survival and the response of normal tissues, as well as the implementation of new quality control programs, are also new achievements to be considered in the progress of RT [Pérez 2007, Murillo 2000, González 2001].

In this specific case, we focus on Intraoperative Radiotherapy (IORT), which is a technique that combines surgery with radiotherapy applied to patients with tumors surgically assessable, resectionable and with a high relapsing level. It entails the direct application of a unique dose of radiation through beams of electrons; for this purpose, the area to irradiate is defined trying to protect healthy tissues through the withdrawal of mobile or displaceable structures or through the protection of fixed ones. In general, it is used as reinforcement (boost) in combination with external radiotherapy [Calvo 2006, Gunderson 1999, Gerard 1997].

In order to give external radiotherapy, a dosimetry calculation is required, from CT images alone or merged with other modalities (such as NMR or PET/CT images) to obtain complementary information. These images introduced in a planning equipment, allow the calculation of the dose distribution by evaluating the interaction of the radiation beams with the interacting tissues.
Thus, one of the current main limitations in IORT lies in the difficulties that the planning process entails. The retraction of the patient’s structures and the removal of affected tissues contribute to the modification of the patient’s geometry. Therefore, it is difficult to carry out a feasible dosimetry calculation from pre-operative images. This fact brings up two problems to the planning:

- **Before surgery:** it is complex to estimate the dose to be applied.
- **After surgery:** since such images are not available, the results cannot be assessed.

In addition, as IORT is an invasive technique that introduces an applicator to reach the tissues to be irradiated, the operatory area has to be adapted in order to reach an ideal position of the remaining parts of the tumor or tumor bed.

Currently, it is very difficult to plan the radiotherapy process beforehand; that is why the surgeons must choose during surgery the cone dimension, its positioning, the bevel angle and the electron beam’s energy according to their medical and surgical experience and the information gathered during the procedure.

This means that the previous dosimetry estimation of the radiation to be applied is not good enough to properly assess, with certain precision, the results obtained (complete scope of the tumor bed, dose on healthy tissues and critical organs, etc.). Therefore the possible beneficial and deleterious effects of irradiation cannot be explained.

The professional willing to simulate or plan an IORT procedure needs a tool that allows them to estimate the cone location and the dose distribution that will be applied to the anatomical volume determined by them. In order to assess the results of a radiosurgery therapy already applied, it would be desirable to know the exact dose received and therefore being able to gather accurate treatment results.

**radiance** provides different functionalities for each phase of the procedure: a segmentation tool that allows identifying areas of interest for the procedure (tumor bed, organs at risk); a simulation tool where the virtual insertion of the applicator in the patient through a surgical frame is allowed; a calculation and dose deposit visualization tool that shows an approximate distribution of the received dose according to the selected cone and beam parameters and, lastly, the possibility of modifying any of them, before and during surgery, adapting them to the intraoperative findings.
SECTION 2
MAIN FEATURES

**radiance** is the only available Radiotherapy Treatment Planning System (RTPS) that has been specifically designed for Intraoperative Radiotherapy (IORT) and the only one that works in such field of radiotherapy.

**radiance** introduces a new step in the IORT procedure, the preplanning phase. In this pre-simulation, it is possible to alter the different parameters of the procedure to evaluate the outcome without stress in the real treatment decision-making process. This pre-simulation can be improved during the treatment, especially with the availability of intraoperative imaging, and after it. Thus, it improves the safety of the global procedure.

**radiance** is a state-of-the-art development unrivalled today worldwide. It uses advanced visualization, simulation and dosimetry algorithms that are far ahead, concerning performance, of any current software. DICOM images are loaded and their volumetric representation built on the fly. The computation of both graphics and dosimetry computation algorithms is almost in real time. The capability of simulation of different tissue densities opens a new era in the planning of IORT. At the same time the measurements required to commission a linear accelerator are reduced considerably as the configuration is based on a model, which, at the same time, helps to better modify that configuration. The reporting capabilities of radiance exceed significantly the current ones, improving the quality of posterior analysis of clinical cases.

We describe below the most noteworthy features of our Intraoperative Radiotherapy Treatment Planning System (RTPS), **radiance**:

1. **DICOM**

**radiance** is fully DICOM compliant, it allows the loading of all DICOM files that reside on a local drive (hard disk, DVD, USB memory).

**radiance** allows the user to bring images from a PACS/RIS system, those images will be temporarily stored locally and deleted once used.

2. **MPR AND VOLUME RENDERING**

A state of the art 3D graphic engine provides high quality Multi-Planar Reconstruction (MPR) and volumetric rendering (VR) of the patient’s image in real time. Both MPR and VR views can be rotated, panned and zoomed in/out with no delay. **radiance** allows fast visualization of very large 3D studies with no preprocessing required.

Different contrast windows and opacity tables can be used to enhance the visualized images allowing the user to highlight anatomic elements and regions of interest.

Interactive geometrical meshes can be added to the views, for instance to exemplify the movement of the applicator or the 3D dose deposit. Also, graphics can be overlayed on 2D views to depict the isodose curves on a certain cross-section.
By allowing manipulation of the views it is possible to place the patient in both supine and prone positions.

3. SIMULATION

\textit{radiance} allows the user to simulate the actual procedure by loading and visualizing CT images of a patient and to find the best parameters involved (applicator’s geometry, accelerator’s energy, etc) so that the dose deposit is maximized on the tumor or tumor bed while being minimized on the regions to protect.

Each of the steps involved during planning with \textit{radiance} is summarized in the following way:

- Navigation on the patient to determine course of action
- Identification of regions of interest
- Determination of Surgical Frame
- Optimization of IORT parameters
- Reporting

Navigation on the 3D study is required to determine the course of action of the procedure. It is possible to navigate along the complete set of 2D MPR views in any orientation to determine the incision to be made during surgery, the location of organs at risk, organs to protect and to be aware of possible complications. Information on current location is always displayed for reference.

The second step refers to the identification of regions of interest. All organs to be irradiated and organs at risk should be delineated. Organs that will be removed during surgery can be virtually extracted from the image. Identification of regions of interest or segmentation is covered in detail in section 1.6.

The following step is related to the definition of a virtual surgical frame. This surgical frame resembles the incision made by a surgeon. Then, the different feasible positions and orientations of the applicator are evaluated following its anatomical restrictions (incisions and organs restrictions, especially bones) and the degrees of freedom of the linear accelerator. Surgeon and Radiation Oncologist can evaluate together the best surgical approach to optimize the access to the area to be treated with the applicator.

Optimization of IORT parameters is achieved by allowing the user to change the geometry of the applicator (diameter, bevel angle), the position and orientation of the applicator and by selecting the energy of the accelerator. Dose calculation can be carried out by superimposing measured data on water phantoms (non accurate, as human tissues vary in density) or by using an algorithm (see 1.5) which that takes into account the densities of the surrounding tissue. A Dose Volume Histogram (see1.6) tool is provided so that quantification of dose deposit on areas of interest is calculated. Whenever any of the aforementioned parameters is changed, or a new accelerator selected, the DVH will be recalculated.

It is important to stress that the movement of the applicator is constrained by the actual degrees of freedom of the LINAC modeled, thus any movement of the applicator is actually plausible and reproducible in a real procedure.

\textit{radiance} allows comparisons of multiple plans, therefore it is possible to establish a comparison between pre-planning results with the post-planning (actual outcome).

The last step covers one of the main deficiencies of the IORT, the need for documenting the procedure. A user can save and print a treatment report that includes planning parameters, snapshots of the simulation and dose-volume histograms (see1.7).

4. MEASUREMENT TOOLS

\textit{radiance} has a complete set of tools to measure distances and angles accurately within the scene.

A rule tool allows the user to measure distances in any of the MPR views through the selection of an initial and end points. This tool is useful to calculate, for instance, the depth of the effective dose on a particular slice.
In addition, an angle measurement tool allows the user to measure sexagesimal angles in any of the MPR views. Users can calculate an angle, by selecting three non-collinear points on the image. This is useful, for instance, to determine the incidence angle of the applied dose.

5. STATE OF THE ART DOSIMETRY

The calculation of dose deposit at any one time, according to the current characteristics of the applicator, is carried out either by superimposing measurements obtained in water, or through a real time computation, which takes into account tissue heterogeneity.

The latter is carried through two dosimetry computation engines which are available in radiance:

- An adapted and validated fast implementation of the Pencil Beam algorithm used in external radiotherapy.
- A parallel implementation of Monte Carlo algorithm.

These computation methods open a new era in IORT dosimetry, offering a more precise view on how radiation interacts with tissue, thereby enabling an accurate therapeutic outcome.

The “Pencil Beam” algorithm for electrons is mainly based on the work of Fermi-Eyges. In this, the authors take into account the multiple Coulomb scattering of primary electrons as the primary phenomenon that produces the probability distribution within a material reached by a conveniently collimated narrow electron beam. This multiple scattering has an essentially Gaussian treatment, or at least can be treated with sufficient accuracy by Gaussian functions. Besides, there are some additional effects which are considered in this implementation such as:

- Stopping radiation production
- Dispersion of individual electrons on large angles.
- Redistribution of the energy of the beam by means of secondary electrons.
- Widening of the electrons range.

Pencil Beam implementation included in radiance takes into account all these effects while having a very fast execution (it takes only few seconds to compute). According to our tests results, it performs far much better than other implementations found in the literature (see references at the end of the document). The limitation of the semi-infinitive layer approach and the poor backscattering modeling is covered by the available Monte Carlo dosimetry engine.

The Monte Carlo engine is a fully parallel implementation which can run in the different cores of the workstation reducing the total computation time to obtain the dose deposit (early experiments give us a computation time of around four minutes).

A complete set of phase spaces have been obtained using Monte Carlo to compute the dose on water of 60.000 annular mono-energetic sources (with a bin of 1 MeV) with different radius. During the commissioning of the system, an iterative algorithm is able to get, in less than two hours, the linear combination of these sources which best adjust to the experimental measurements (PDD and profiles) for the specific applicator, energy and bevel.

By using CT images, radiance takes into account the necessary information on radiation attenuation of the tissues for dosimetry calculation. For any other type of images the computation algorithm will not handle the different densities of the tissues, assuming the tissue as water for computation purposes.

The system allows the selection of an applicator with the following characteristics:

- Diameter of the cone.
- Energy of the electron beam.
- Bevel angle of the cone.

Additionally, dose calculation with radiance enables the normalization of the dose with respect to a reference point. For this point, an absolute dose value as well as the isodose percentage will be specified.

Having provided all these parameters, the application will calculate the number of monitor units necessary for the accelerator to provide the prescribed dose.

On the other hand, the number of measurements needed to commission a new linear accelerator is considerably reduced by radiance. For instance, a new accelerator’s configuration consisting of five cone diameters (4, 6, 7, 8 and 9 cm), five energies (6, 9, 12, 16 and 20 MeV) and four angles (0°, 15°, 30° and 45°), would normally require 440 profiles and 150 point measurements for a normal characterization, whereas with radiance, only 50 profiles and 75 point measurements are needed. The other remaining measurements are simulated by the algorithm, thus reducing measuring time.

radiance allows simulation (designing and testing) of bolus and protections before the actual treatment.
Protections and bolus are special type of segmentations that can be created by the user.

Sometimes, depending on the location of the area to be treated, the user may wish to protect surrounding regions which need to be spared from irradiation. For this purpose external elements manufactured with specific materials, from which density and effect on the attenuation of radiation have been previously studied, are used.

A user can add as many protections as needed. Protections are normally defined by rectangular boxes (although other methods are also available) that can be positioned, oriented and resized in 3D space at will.

Users can change the density of a protection at any time in the same way as other segmentations. Therefore, by assigning different densities we can simulate bolus, protections and even air.

In the following figure, the difference between using and not using a Pencil Beam algorithm can be seen in a rectal cancer (left column), the effect of using and not using protections in a breast cancer case can also be seen (right column).

6. CONTOURING AND DVH

The contouring tool is used to identify the areas of interest in the procedure, i.e., the regions to be treated, the regions to be protected and the regions that are resected during surgery.

These regions can be shown/hidden, outlined or removed from the image to simulate the resected tumor.

The process is carried out by manual contouring by means of polygonal, free hand or pearl tools. Refinement of contours can be achieved by allowing union/difference/intersection operations of that contour against another as well as scaling and moving tools. A copy/paste tool is also provided so that a base contour can be copied across slices.

In order to minimize user interaction an interpolation of contours is also provided: This allows the reconstruction of a whole 3D region based on a few contours located in non-consecutive slices, this speeds up the process and reduces errors.

A Dose Volume Histogram (DVH) is computed over all regions (risk areas or those to protect) and allows the user to optimize the treatment parameters prior to the treatment. The modification of any parameter during planning (location, orientation, or geometry of the applicator and LINAC’s energy) implies an automatic recalculation of the DVH.

7. REPORTING

The current absence of a complete and homogeneous method for documenting IORT procedures is one of the main limitations when comparing the results and complications of this technique. When the results from an IORT clinical program are presented, the parameters that are generally documented are the energy and the applicator parameters (energy, diameter and angle).

radiance stores all treatment information generated by system, including not only the beam energy and the applicator parameters (energy, diameter and angle), but also position and orientation (with respect to the patient and the LINAC), regions information, dose volume and isodose curves, linear accelerator configuration as well as all snapshots that the user might have generated. This way, the case can be reproduced quite easily and be compared against another. Radiance allows the use of templates so that
the information is structured in the format required by the user.

This documentation can be stored before the treatment (during pre-planning), before the treatment (especially if there is a capability to generate intraoperative imaging) and also after the actual procedure, recording all the final amendments of the original plan. Reports can be exported to PDF format so that they can be printed and easily exchanged with other people.

8. WORK GROUP

Planning studies can be exported to other stations. The remote visualization tool allows users to share their plan with another remote user in real-time. It is possible to communicate with remote users via chat or audio/video so that real time interaction is achieved.

radiance is a communication tool among all specialists involved in IORT: radiation oncologists, surgeons and physicists. For instance oncologists might consider discussing a plan with a surgeon in order to see if the position/orientation of the applicator is feasible after surgery.

Users can assess the plan with other colleagues (either in the same station or in a different one) before putting it into practice, thus making substantial improvements in the safety of the procedure.

Additionally, this same remote tool is used as a communication tool between GMV and the customer, reducing the response times for technical support.

9. HW CONFIGURATION

The software is preinstalled in a workstation which is also provided.

At the time of publishing this paper the reference HW configuration is a Dell OptiPlex 990 DT with the following characteristics:

- Windows 7 Home Premium (64-bit)
- i7-2600 Intel® Core™ Processor (8M Cache, 3.40 GHz)
- 4GB Memory
- 2x 500GB Hybrid HD SATA II, RAID 1
- AMD Radeon HD 6450 graphics card with 1 GB dedicated memory
- DVD 16x, +/- RW
- Optic wireless mouse and keyboard
- P2311H: 2 LCD LED 23", Full HD (1920x1080), UltraSharp Monitor displays.
- Microsoft Security Essentials
- Teamviewer 6.0 (for remote maintenance)

Currently, this configuration matches a high-end PC. The configuration to be upgraded as new technology is available.
SECTION 3
VALIDATION STUDIES

10. VERIFICATION AND VALIDATION OF DOSIMETRIC ALGORITHMS

With the aim of doing a more precise dosimetric calculation, the initially developed Pencil Beam algorithm has been adapted to external radiotherapy for IORT. The resulting algorithm takes into account the heterogeneity of the patients, the applicator bevels and the possibility that the Skin Source Distance (SSD) may not be constant. The algorithm has been implemented in *radiance*, finally achieving a computer tool that enables to carry out the virtual simulation of the treatments and to obtain precise 3D dosimetric calculations of the doses to be applied to patients.

In order to verify the correct operation of the planning tool, it has been carried out the tests described in the Protocol for Quality Assurance in Therapy Planning Systems with ionizing radiation, by Spanish Society of Medical Physics (Sociedad Española de Física Médica), as there is not any specific national or international protocol for intraoperative radiotherapy planning tools, being the present product the first planning tool of this kind.

In a preliminary phase, simulations have been compared against measurements in a water tank with a very good agreement between them, as shown in the following pictures. All different energies, diameters and bevels combinations for two different configurations of IORT (different LINACs and different applicators design) were compared at this time.

In a second phase, simulations were compared against measurements by adapting the mentioned protocol tests for TPS to IORT with different heterogeneity configurations:
- Solid water step
- Lung (type chest wall and mediastinum-lung)
- Bone
- Shielding disks for breast IORT

The following results were obtained:
- Solid water step (gamma test)

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In the latter case, a limitation appeared on top of the shielding disk, because Pencil Beam algorithm cannot model backscatter radiation. Nevertheless, the modeling of the attenuation underneath the disk was in good agreement with measurements.

In the QA Protocol mentioned above the recommended tolerances for electron beams are, generally much more restrictive, being in certain cases around 2% or 3%. However, the recommendations documented so far indicated that a tolerance of ± 5% between the prescribed dose and the applied dose in IORT was acceptable.

Keeping in mind that the results are within the limits described in the Spanish Protocol, we have estimated that the compliance of its specifications is more than acceptable.

Experimental verification measures have been carried out by different hospitals: Clínica La Luz (Madrid, Spain) and Hospital de Castellón (Comunidad Valenciana, Spain).

11. CLINICAL VALIDATION STUDIES RESULTS

Several studies have been performed to evaluate the feasibility and clinical utility of radiance in the planning of intraoperative radiotherapy treatments. Results have been presented in the most important congresses of the specialty.

In the first study, 36 cases have been gathered in the Hospital Universitario Gregorio Marañón and a representative subgroup of 15 has been simulated by three radiotherapy oncologists.

The conclusions of that study are the following:

- radiance is an intuitive planning system that properly simulates the parameters that must be decided in IORT procedures.
- The possibility of studying several planings improves the preparation of the specialist for the real situations to be afforded during the procedure.
- radiance allows discussing the best approach for a concrete case and eases the specialist to analyze a simulation prepared by another one. This exchange of specific information about an IORT treatment is an essential contribution to the system.
- The cases and the simulations gathered are type cases that will allow specialists to quickly learn to use radiance. This learning will also allow studying IORT procedures from an approach that would not possible without radiance, as it allows checking what happens when modifying the treatment parameters.

Further studies on the usage of PB (Pencil Beam) for specific locations (please refer to the documentation in section 1.14) showed that PB dose modeling has identified several aspects of IOERT (Intraoperative Electron Radiotherapy) treatment that cannot be evaluated with conventional water phantom measures. radiance IOERT simulation and planning system moves one step forward to more precise dose estimation by the inclusion of this algorithm. The use of PB allows quantifying and predicting the influence of several parameters in this IOERT breast model.

Comparisons between different Oncologist Radiotherapists (ORs) showed that the ORs provided completely equivalent plans for 65% of the cases evaluated, and this percentage increases up to 85% if the RO has information about the surgical procedure. This suggests that simulation has to be carried out with specialized surgical input, which will set the criteria to select the surgical access and help in the definition of the high risk areas. When there is agreement in the surgical protocol, and there is information from the surgical procedure, all ORs provided equivalent simulations.
12. SUMMARY

Intraoperative Radiotherapy, IORT, is a kind of therapy that allows the incorporation of a dose absorbed in a single session through high-energy electron beams to cancer treatment. This is done during surgery in a non-resected tumor or at the surgical site, while normal (non-tumoral) tissues are displaced from the beam of radiation. The advantage provided by IORT is the possibility of carrying out a visual and palpable demarcation of the tumor, and also of excluding the risk structures from the radiated field, whether by displacing or protecting them.

So far, there was no commercial planning tool available on the market for treatments with this technique; a manual dosimetry was carried out based on the distribution of water-measured doses.

The use of a planning tool adds numerous advantages to this type of treatment, along the lines of the recommendations of the AAPM working groups (Task Force 48 and Task group 72) that are considered an international reference in this matter and are widely cited in all the IORT bibliography.

The main improvements achieved with the use of the planning tool are the following:

- It makes possible to know the exact depth and lateral extent of the tumor by different means other than the direct manipulation during surgery or ultrasound. Thus, it is possible to choose the optimal electron energy and the appropriate size and shape of the cone in order to achieve the recommended coverage of 90% (TG 48).

- It enables real dose distribution in the patient and the volumes of interest, unlike the standard calculation, that only permits to determine the dose in a certain point (approx.) and MU (Monitor Units) calculation (approx.).

- In case the areas to be treated are larger than the size of the measured cones, it enables the estimation of the overdose and the undertose in the intersection area between two cones. This point is important, as dose given in one-session treatments are very high. TG48.

- The monitor units must be checked twice. The planning tool is the only independent means, apart from manual calculation, to that purpose as opposite of using the same equation in a spreadsheet. TG48

- As it is a single fraction technique, it is essential to verify that the dose has been administered in the correct anatomic location and at the desired depth (TG48). Current methods, such as photography, online monitoring and ultrasound are not as accurate as a CT image, which is also the only type of image that permits the use of the information on the tissues’ real composition in the calculation of the dose.

- The difference in the deposition of the dose for soft tissues and bones depends on the energy. In a manual calculation this is not taken into account, whereas the planning tool can simulate it. Validation tests have been carried out to prove this point.

- It makes possible to calculate the dose for tissues and critical organs, unlike in usual calculations (TG48), which must be reported for all radiotherapy treatments, according to Spanish Royal Decree 1566/1998 on Quality Assurance criteria for radiotherapy.

- The use of a planning tool is the most effective way of “carrying out an individualized clinical dosimetry under the supervision and responsibility of an expert in hospital radiophysics, according to the prescription of the specialist doctor”, as stated in the RD 1566/1998, sections 2 and 3.

- It permits to obtain the maximum and minimum doses to PTV (Planning Target Volume). Such doses must be included in the final report according to the ICRU 71 (they are not estimated in manual calculation).

The final recommendations document of the TG-72 for mobile accelerators specifies that all aspects related to possible modifications of electron beams must be examined: gaps, bolus, tissue heterogeneity, and that it is necessary to develop IORT treatment planning tools able to reproduce real treatment situations.

Taking into account everything previously considered, we estimate that the validity of a specific planning tool for Intraoperative Radiotherapy is perfectly justified.
13. TESTIMONIALS

"IORT parameters can be defined the day before to the treatment 90% of the times, [...] the system enhances the capabilities of documenting the process for posterior analysis". Prof. Felipe Calvo, Oncology Department Director, Gregorio Marañon University Hospital, Madrid.

"It is an important advance in the history of IORT [...] The preplanning phase is an important improvement in the IORT treatment of breast cancer [...] Brest surgery can be previously predicted and the different parameters of the treatment can be defined beforehand", Prof. Roberto Orecchia, Radiotherapy Division Director, Istituto Europeo di Oncologia, Milan.

14. PUBLISHED PAPERS, BOOKS AND PRESENTATIONS IN CONGRESSES

15. REFERENCES


5. ICRU REPORT No. 71 “Prescribing, Recording, and Reporting electron beam therapy” the International Commission on Radiation Units and Measurements, June 2004.