

spectroscopy at HFR. The reporting of the absorbed dose of each dose component and a biologically weighted dose is based on the actual blood boron concentration and applied monitor units.

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POSTER

### The elekta multileaf collimator (MLC). A universal soldier made to conform

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**Purpose:** To reduce the limitation imposed by the 1.0 cm leaf width to a level analogous to customised blocks. Apply techniques to small fields (2.0 cm), where block manufacture is most difficult and inflexible.

**Methods:** The MLC was originally investigated using a water tank and small 0.125 ion chambers. For small fields diodes and film were used. The leaf was investigated as a stand alone device over its full range of travel and all locations. Combinations of leaves and a range of geometric shapes were investigated. The leakage between leaves as applied to the patient was measured for both simply and worst case scenarios, using the test shapes.

**Results:** The effect of small penumbrae changes over the leaf travel, were considered negligible for clinical purposes. No field joins were used thus no hot or cold spots were introduced.

**Conclusion:** The basic techniques have been used clinically since 1994. Dose escalation and a head/neck trial using a stereotactic frame and small conformal MLC fields is now in progress.

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### HDR boost brachytherapy with flexible implants in breast cancer

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**Purpose:** Brachytherapy is undergoing a resurgence based on new radiobiological concepts. The purpose of this study is to report the preliminary findings with a technique of high dose rate (HDR) boost brachytherapy with intraoperative implantation of flexible catheters following breast cancer conservative treatment.

**Methods:** Between August 1996 and August 1998, 43 cases with pathologically staged I-II breast cancer were treated with breast conserving surgery and intraoperative placement of 6 french hollow plastic catheters in the tumor bed under direct control. All patients received at least two sessions of 400 cGy each of them, starting 6 at 24 hours after surgery with a microSelectron HDR unit. This was followed by external beam irradiation to the whole breast at 200 cGy/day for 25 fractions.

**Results:** With a minimum follow up of 6 months and a maximum of 30 months, ninety three per cent of the patients had no radiogenous skin changes in the boost area. In 6.9% (3/43) minimal punctiform hypocromic lesions appeared at single puncture sites. Eighty nine per cent of the patients judged the cosmetic result as excellent or very good. There have been only one (2.3%) local recurrence presented as inflammatory breast cancer 23 months after treatment.

**Conclusions:** Perioperative irradiation has the radiobiological advantage of delivering high dose rate immediately upon removal of gross tumor to residual microscopical disease. Intraoperatively implantation increases the accuracy of placing the boost dose, avoiding geographical error. This technique seems to be a safe method to boost the tumor bed, without severe acute effects, eliminating the need of rehospitalization and anesthesia and shortening the overall treatment time. In conclusion, in spite of short follow up, perioperative HDR boost brachytherapy with flexible implants appears as a promising technique. A longer follow up is required to analyze the local control rates.

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### Past, present and future trends of boron neutron capture therapy (BNCT)

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The authors intend to provide an overview on the development of BNCT, to summarize the study design and the results of the ongoing clinical trials and to present the trends of preclinical and clinical research activities. The analysis of the disastrous clinical experiments in the 1950s and the reports on intraoperative BNCT in Japan led to a revival of the interest toward the promising principle of BNCT. Development of <sup>10</sup>B delivering drugs, tissue uptake and toxicity studies, facility design, physical characterization of thermal, epithermal and fast neutron beams, radiobiological studies, and early clinical trials have been performed in the last years. The status of BNCT research is summarized, focusing the clinical studies in USA and in Europe. The widening of investigations at the enhancing of fast neutron therapy by BNCT will be analyzed. Necessary steps to develop standards for BNCT are suggested. Proposals for integrated efforts for future research, activities are addressed

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### Hyperfractionated body stereotactic radiosurgery (BSR)

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**Purpose:** BSR is a non-invasive approach using an external stereotactic frame to deliver precision radiation most anywhere in the body. Like brain radiosurgery, treatment is directed at the defined target using multiple finely collimated radiation beams while minimizing dose to healthy, normal, surrounding tissues. The objective of this analysis is to determine the control rate of stereotactically treated primary and metastatic cancers in patients (pts) not amenable or not successfully treated with standard therapy.

**Method:** In the Western Hemisphere's first location in the first two years Of BSR, 834 pts completed therapy. 194 pts aged 23 to 86 years (mean 62) with 261 tumors having a volume range of 0.07 to 5,240 cc (mean 208.9 cc) were evaluable. Dose per fraction ranged from 250 to 1000 Centigray (cGy) (mean 767.6 cGy) delivered in 4 to 8 (mean 5.06) fractions. 38% of cancers were pulmonary with 38% metastatic and 62% primary. 29% of cancers were hepatic with 89% metastatic and 11% primary.

**Results:** Control is defined as cessation of growth, shrinkage or disappearance. 108 cancers (41%) ceased growing while 120 cancers (46%) decreased in size. 33 cancers (13%) increased in size. The overall extracranial control rate for BRS was 87%. Therapy was administered with little untoward effects.

**Conclusion:** BSR results in a high control rate especially considering pts had extensive previous treatment with surgery, radiation and chemotherapy. BRS is well tolerated and warrants further investigation for those seeking high dose precision radiation. Improvement to patient care should be expected to include better local control and palliation of symptoms.

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### Advanced on-time treatment planning for Intraoperative radiotherapy (IORT)

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**Purpose:** In IORT with electrons, it is common to use iso-ionisation catalogues acquired from water phantom measurements directly for the estimation of dose distributions. However, the actual surface of a treated region frequently differs significantly from the plain conditions in a phantom. This leads to large uncertainties in real dose delivery, especially when beveled cone applicators are used on curved contours.

**Methods:** A dedicated IORT planning system was developed, allowing for on-time calculation of the dose distribution beyond curved surfaces before treatment. Geometric information of the surface contour and tissue inhomogeneities (bones, lung) are acquired by a simple mechanical device

or by ultrasound, respectively. The planning algorithms convert iso-ionisation matrices into iso-energy dose matrices [Gy]. Corrections are performed for varying energy absorption, for altering SSDs, for asymmetric small angle electron scatter from the applicator wall as well as for lateral electron scatter within the irradiated volume.

**Results:** Individualized planning was done for patients with head and neck and rectal cancer, prolonging the IORT procedure by 2–4 minutes. In all cases, the graphical display of real dose distributions permitted the appropriate selection and mixing of beam energies. Monitor units were calculated in order to match the target volume with the prescribed dose.

**Conclusions:** Treatment planning for IORT can be done on time. Confirmation and reliability of the applied doses are increased.

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### Variation in dose distribution for breast radiotherapy: A trial based quality assurance programme in the UK

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**Introduction:** An integral part of the START (standardisation of breast radiotherapy) fractionation trial in the UK is a detailed QA programme implemented by a dedicated team. The team has visited thirty-one departments, which have indicated an interest in the START trial, to evaluate their breast radiotherapy techniques. Two 2D phantoms have been designed to measure the dose at points through the breast and chest wall. These measurements are compared to plans generated by the department.

**Results:** 12 different planning systems are used across the 31 centres, 8 are commercial and 4 locally designed. Various energies were used to treat the phantoms; 24 departments used 6 MV, 4 used 5 MV, 2 used 4 MV and 1 used cobalt. 15 departments applied a lung density correction. A variety of weighting and wedge combinations were used. Dose distributions fell into one of three patterns: 'hot spots' close to the breast surface, the chest wall or equal dose throughout. The mean measured dose at the reference point, for an expected dose of 4 Gy using a linear accelerator, was 3.94 Gy (S.D. 0.04) and 3.91 (S.D. 0.07) for breast and chest wall phantom respectively. For Cobalt 60 mean results from 3 departments on the breast phantom were 3.83 (S.D. 0.03). The dose gradient between the apex of the breast and the lung surface was within the 10% required for the trial for 28 of the 31 departments.

**Conclusion:** Variations in planned distribution and reference doses have been demonstrated across 31 centres studied. In general, doses calculated by the planning system are slightly higher than those measured in the phantom.

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### 3D planning for tangential breast irradiation: Feasible and relevant?

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**Purpose:** to evaluate the practical use of CT scan for the simulation of the breast and the impact of 3D-planning on dose homogeneity.

**Methods:** 11 patients with early stage breast cancer were simulated using 2 tangential fields (arm position in 90° abduction). Using a simulator with CT option 3 CT slices were taken first in treatment position and then in a modified position (with the hand on the head) which permits passage through a conventional CT scanner. Finally a complete CT scan (1 cm slices) with this modified arm position was performed at the radiology department. Different distances and angles on the central axis plane of these 3 modalities were compared to evaluate the effect of the arm position on breast configuration and treatment. The clinical target volume (breast) was outlined on the complete CT scan and virtually simulated. Different treatment plans, based on the central slice, on 3 slices and on all slices of the complete CT scan were made. The hotspot (>107%) on the total volume of the breast and the volume of the breast receiving less than 95% or more than 107% of a 50 Gy midline prescription, were calculated for each of these plans.

**Results:** Small differences in arm position appeared to have a limited effect on breast configuration. But comparison of the standard treatment plan based on 3 CT slices (simulator) with the treatment plan based on CT scan of the radiology department showed an important impact on dose homogeneity. The second part of this study indicates that differences in "ICRU-treated" breast volume between planning based on 1 or 3 slices

were minor. Only planning based on full CT resulted in an important amelioration of dose homogeneity and hotspot.

**Conclusions:** 3D planning for tangential breast treatment is feasible as long as the arm position does not change between simulation and CT planning. Planning on a complete CT scan results, even for small breast, in a more homogenous CTV dose distribution than planning on 1 or 3 slices.

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### Total body irradiation – Prospective evaluation of early side effects

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**Purpose:** Since 12/1997 total body irradiation (TBI) as part of conditioning therapy before BMT or PBSCT is provided in our clinic. We use the translation method established by Quast (Essen, Germany) where the patient is moved slowly through a radiation beam lying on a translation couch (focus-couch distance: 207 cm). We developed a detailed follow-up program in order to evaluate any early and late side effects according to Common Toxicity Criteria (CTC) (1997).

**Methods:** Until 01/99 hyperfractionated TBI (12.6 Gy, 2 × 1, 8 Gy/day, lung dose <10 Gy) was performed in 26 patients using a 6 MV photon beam (linear accelerator; dose rate: 1 Gy/min in 207 cm) (dose inhomogeneity: <10%). Underlying diseases were ALL (n = 8), AML (n = 6), NHL (n = 10) and other (n = 2). Radiogen side effects were registered at day –7, day –4 before and day +90 after transplantation.

**Results:** We observed no toxicity grade III–IV at day –4 except of leucocytopenia (30%), thrombocytopenia (12%) and alopecia (76%). At day +90 the corresponding data were 6%, 26%, and 53%, respectively. Other side effects often observed (toxicity grade I–II; day –4/day +90) were nausea (65%/6%), skin erythema/dry desquamation (46%/33%), mucositis (30%/26%), vomiting (26%/6%), xerostomia (26%/46%), loss of appetite (26%/13%), headache (20%/0%), and diarrhea (0%/20%).

**Conclusion:** We present our first prospectively evaluated data demonstrating that TBI under translation condition is securely feasible and that toxicities grade III–IV are seldom observed at day –4 and day +90 after BMT or PBSCT.

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### Is the vaginal rod an accurate method to localise the vaginal apex?

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**Purpose:** To determine the accuracy of the radiopaque vaginal rod method in localisation of the vaginal apex, compared with contrast vaginography.

**Methods:** Twelve patients, who needed pelvic radiotherapy, were studied on the simulator. Each patient had AP and lateral X-rays using contrast in the vagina, with and without the rod positioned against the apex of the vagina. The contrast medium was a Diatrizoic acid 50% vaginal gel developed by two of the authors (TJW and AvS). The hypothesis was that the anatomical position of the vagina, displayed using vaginography, was changed by the rod. On the X-rays the distance from the top of the rod to the apex in anatomical position was measured in mm in the craniocaudal and dorsoventral direction and called the inaccuracy (of the rod method). The resulting total inaccuracy in the sagittal plane was calculated using Pythagoras' law. Furthermore, the size of the vaginal vault was measured in the transversal plane, using the contrast vaginography.

**Results:** The inaccuracy ranged from 0 to 19 mm in the craniocaudal direction (median 9 mm) and from 0 to 22 mm in the dorsoventral direction (median 7 mm). The resulting total inaccuracy in the sagittal plane ranged from 6 to 22 mm (median 14 mm). The maximal width of the vagina measured on the AP film ranged from 32 to 68 mm (median 40 mm); measured on the lateral films it ranged from 5 to 17 mm (median 10 mm).

**Conclusion:** The distance from the top of the vaginal rod to the apex of the vagina in anatomical position varies from 6 to 22 mm; therefore the rod is an inaccurate method to localise the vaginal apex. Furthermore the rod gives no information on the actual size of the vaginal vault. Contrast vaginography is the method of choice to localise the vagina.