PERFORMANCE REPRODUCIBILITY OF INTRAOPERATIVE RADIOTHERAPY EQUIPMENT

PHOTON RADIOSURGERY SYSTEM

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Introduction

Intra**O**perative **R**adio**T**herapy (IORT) is defined as the delivery of a single, large radiation dose to the bed of a resected tumour at the time of surgical intervention.

The past 20 years have seen a distinct shift in the approach used in the treatment of breast cancer, away from radical interventions toward more conservative techniques.

Randomised clinical trials have shown that breast conserving surgery allied to external beam radiotherapy compares favorably with more radical procedures such as mastectomy.

However, the radiation fields still encompass all of the breast tissue – healthy and cancerous.

Intraoperative radiotherapy using the Photon Radiosurgery System avoids unnecessary treatment of the whole breast and delivers a critical dose to the tumour bed only.

We are investigating whether a single high dose with IORT imparts the same clinical benefit as external beam radiotherapy (typically 6 weeks).

Equipment

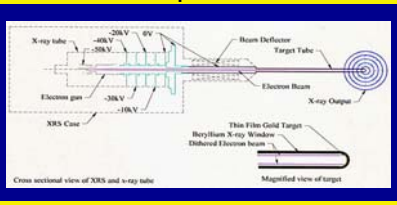
Ninewells Hospital has four Intrabeam™ X-ray sources (Carl Zeiss Surgical, Germany) currently used to treat breast and neurological tumour sites.

Each Photon Radiosurgery System (PRS) comprises a miniature X-Ray Source, controller, mobile gantry and QA tools.

The Miniature X-Ray Source

Weight 1.62 kg. Dimensions 17.5 x 11 x 7 cm with a 3.2 x 100 mm long chromium nitride coated probe. Tip probe made from beryllium (0.5 µm). Dose distribution in spherical pattern. Dose rate in tissue of ~ 2.5 Gy/min at 10 mm from probe tip.

Operation



Methods

Performance of four x-ray sources was compared over a period of seven months, (ongoing).

- ❖ Device Intercomparison
- ❖ Half Value Layer
- ❖ Depth Doses in water
- ❖ Output Trends
- ❖ Internal Rate Monitor (IRM) reproducibility
- ❖ Output Decay Factor
- ❖ Accuracy of treatment time.

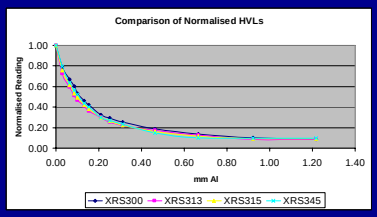
Results

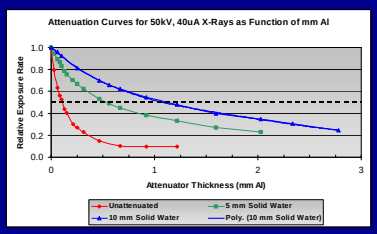
The **Half Value Layers** for all XRS were determined by a broad beam method; probe 20 cm from IC, Al attenuators near the midpoint.

Attenuator thickness ranged from 0.03 to 3.00 mm.

To quantify beam hardening at prescription depths, 5 and 10 mm of solid water attenuators placed ~ 2 cm from probe.

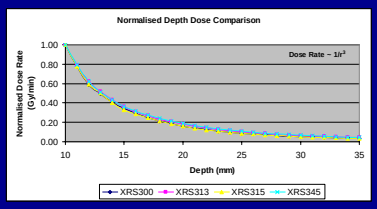
For unattenuated beam HVL ~ 0.11mmAl.
At 5 mm in solid water HVL ~ 0.54 mmAl.
At 10 mm in solid water HVL ~ 1.11mmAl.





Depth-dose curves were obtained by measuring the IC output at 10-35 mm from probe tip in water.

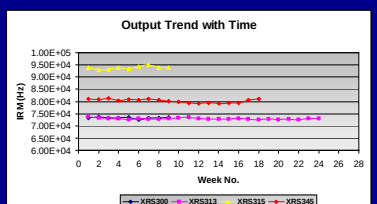
Custom-built water phantom soft x-ray parallel plate IC used.



Output trend - Weekly calibrations performed on four x-ray sources.

An internal rate monitor (IRM) test procedure used to check the response of the IRM.

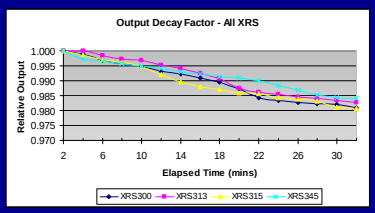
The IRM count rate obtained during this verification procedure is used in clinical treatment time calculation.



Output Decay Factor - To determine constancy of output - chamber current monitored over a period of 30 mins. (typical clinical treatment time).

Average output level over 30 mins. was 99.12%.

Factor is small but for the purposes of accuracy, may be included in the dose calculation.

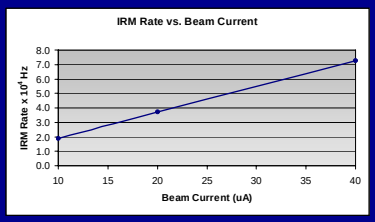


IRM Linearity with Beam Current

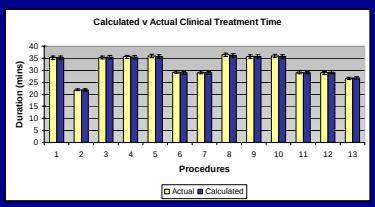
Linearity of the IRM dosimetry system was determined at 50kV for a range of beam currents.

Number of counts set to 5 x 106 and beam current set to 10, 20 and 40µA.

The IRM rate varied linearly with beam current.



Clinical Treatment Times - mean difference between the calculated and actual treatment times for breast patients was 0.45% and for brain patients it was 0.40%.



Radiation Protection in Theatre - Risk assessment performed as per IRR99. Ambient dose rate @ 1m from the treatment site without shielding, 10 $mSv.hr^{-1}$.

Need mobile Pb-glass screens (2mm).

Dose rate < 2 $\mu Sv.hr^{-1}$ behind screens. We use additional flexible rubber-coated lead shielding at the treatment site.

Conclusions

- ❖ The four x-ray sources have proven to be stable over time.
- ❖ Measurements were found to lie within the manufacturer's tolerances.
- ❖ Intercomparison shows that the x-ray sources have similar performance characteristics.
- ❖ Additional radiation protection measures are necessary in theatre.

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