

Intraoperative Radiotherapy using very low energy X-Rays

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IORT in the UK

Two IORT centres -

- Ninewells Hospital and Medical School (Dundee)
Treat approx. 35 patients per year.
- University College (London)
Treat approx. 30 patients per year.



IORT worldwide

Other Centres participating in the international clinical trial (TARGIT):

California (2), Lafayette – US (3)

Mannheim, Berlin – Germany (2)

Perth, Melbourne – Australia (2)

Lublin – Poland

Aviano, Firenze – Italy (2)

Approximately 500 patients treated for early stage breast cancer.

Need 2000 for trial.

Ninewells Hospital (Dundee)

- Large teaching hospital providing care for population of approx. 0.5 million
- Oncology Service to 1400 new cancer patients annually.



3 Linear Accelerators (Varian) • HELAX Treatment Planning
IORT • LDR Brachytherapy • PLATO Brachy Planning System
Pantak DXT300 • Simulator (CT Ext.) • VISIR • Mould Room

What is IORT?

- ◎ **I**ntra**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.
- ◎ In early stage breast cancer, IORT avoids unnecessary irradiation of the whole breast [1].
- ◎ We are investigating whether a single high dose imparts the same clinical benefit as external beam radiotherapy (typically 6 weeks).

[1] Vaidya JS, Baum M *et al*. The novel technique of delivering targeted intraoperative radiotherapy (Targit) for early breast cancer. *Eur J Surg Oncol*. 2002;28:447-54.

The Potential of IORT

In breast cancer, IORT may potentially replace EBRT in the treatment of stage I patients undergoing wide local excision (WLE).

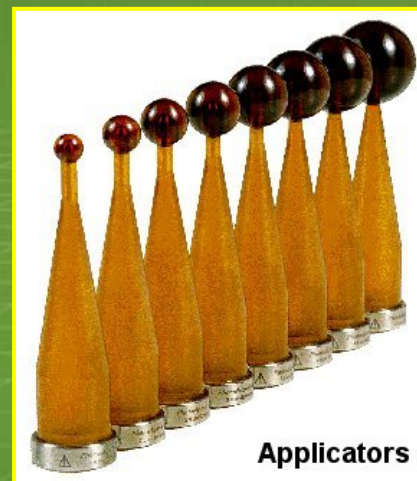
These patients represent about 33% of the projected 2011-2015 EBRT breast cancer workload (Scotland) and therefore, if IORT is proven to be clinically effective a considerable workload would be directed away from external beam services [2].

“... if IORT replaces EBRT for early breast cancer this would have a *profound effect* on the requirement for machine capacity”.

[2] Scottish Executive Health Department (2005) Cancer in Scotland: Radiotherapy Activity Planning for Scotland 2011 - 2015. Edinburgh: The Scottish Executive.

IORT Equipment at Ninewells

- ◎ Four Intrabeam™ X-ray sources (Carl Zeiss Surgical, Germany).
- ◎ Currently used to treat breast and neurological tumour sites.



1.5 – 5.0 cm



IORT Equipment at Ninewells

Eight Applicators
ranging from 1.5 to 5.0
cm diameter.

Sterilised using ethylene
oxide (EtO).

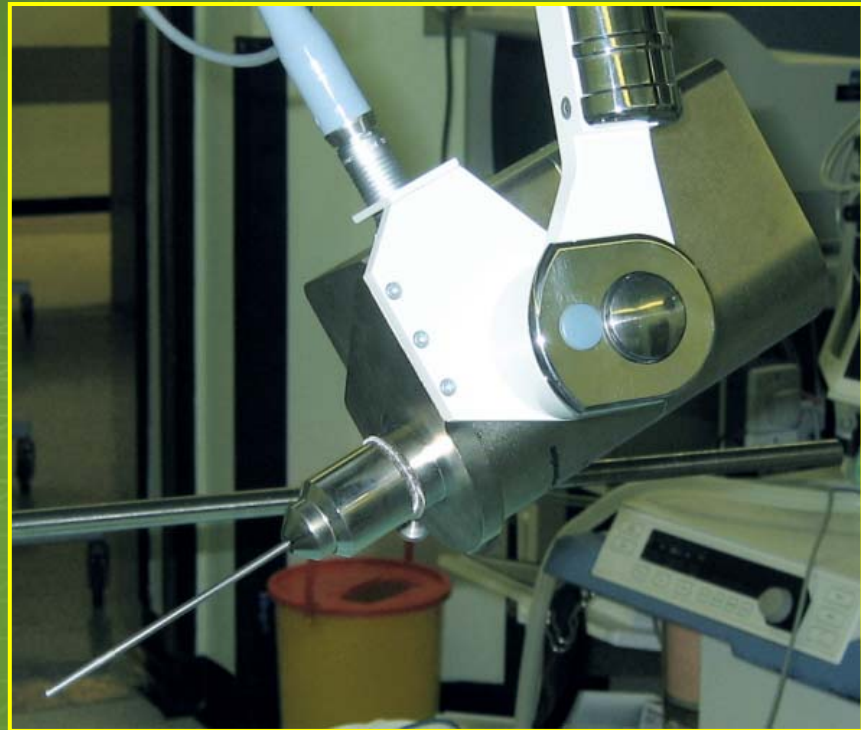
Usually sterilised as a
unit.

We have found it more
practical to sterilise
individually or in small
groups.



The Miniature X-Ray Source

© Each XRS weighs 1.62 kg, has dimensions 17.5 x 11 x 7 cm with a 3.2 x 100 mm long chromium nitride coated probe.



Pre-treatment Verification

Four tests need to be performed prior to clinical use.

Takes approx. **45 minutes** and usually done evening before operation by a physicist.

Not done in theatre.

XRS wrapped in sterile surgical drape.



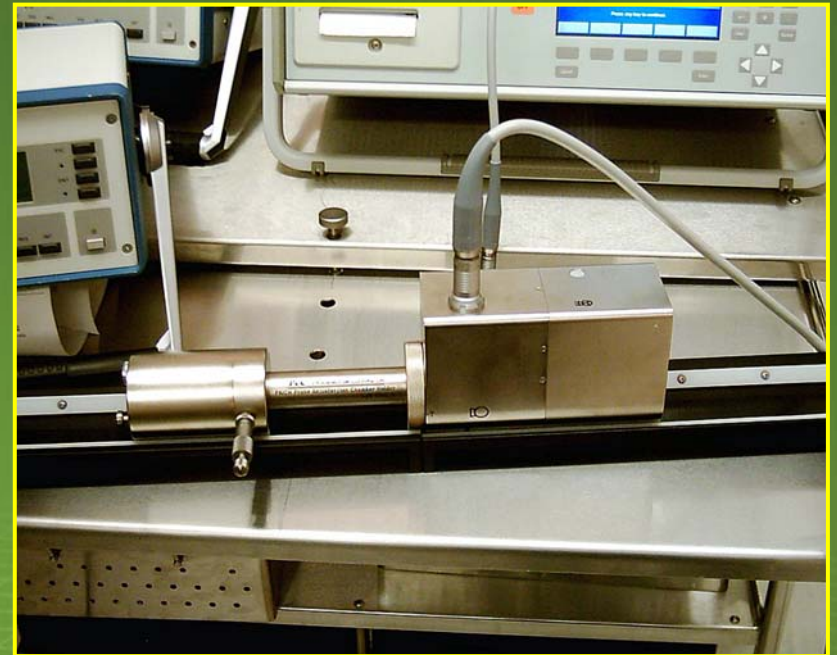
Quality Assurance Tools

(1) Probe Adjust

Used to verify and adjust the straightness of the XRS probe to ensure proper alignment during treatment.

Manufacturer's tolerance:
0.100 mm

Local Tolerance:
0.060 mm



Quality Assurance Tools

(2) Isotropy Adjust

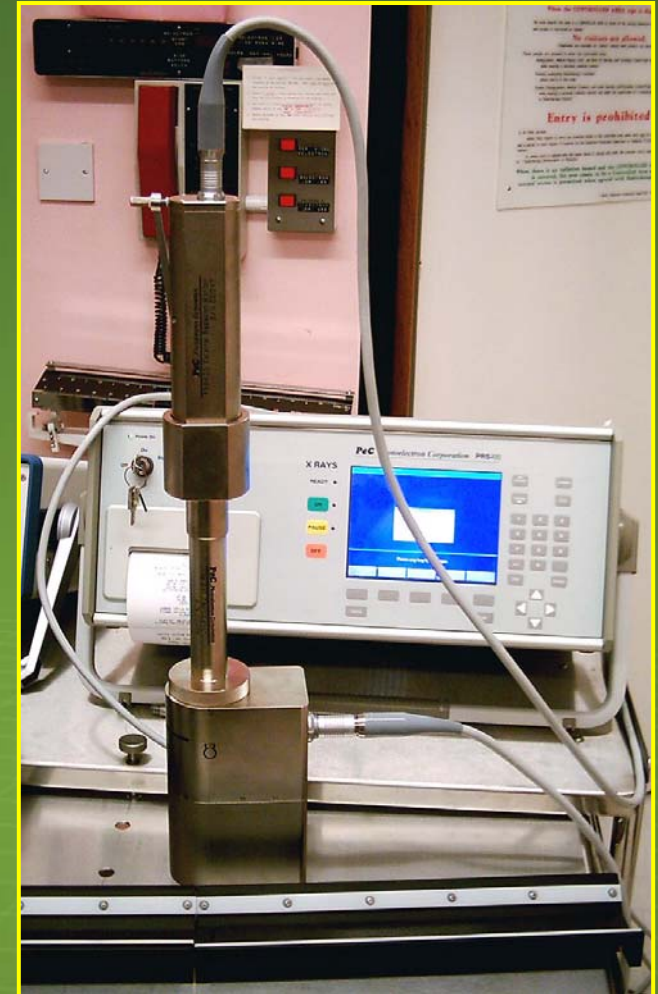
Used to adjust the x-ray field generated by the probe to produce a more isotropic distribution.



Quality Assurance Tools

(3) Test IRM / ERM

Used to check the count rate of both the Internal and External Radiation Monitors against expected values to ensure proper functioning of those devices.



Quality Assurance Tools

(4) Read Ion Chamber

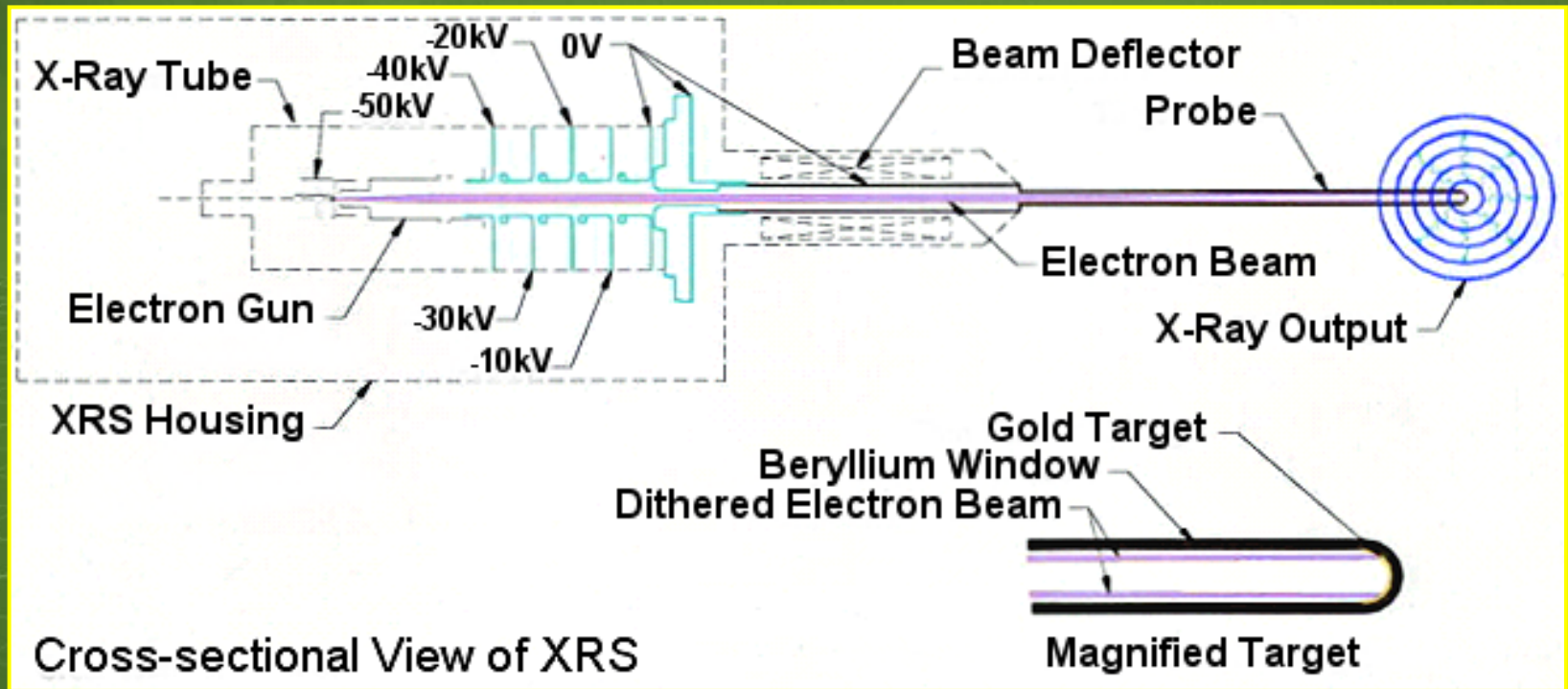
Enables the operator to measure, then enter, the IC value, as read by the electrometer, to the Control Console.

This allows the detected strength of the x-ray field produced by the XRS probe to be corrected for T and P.



How does it work?

- ◎ Beam accelerated through field (up to 50 kV).
- ◎ Beam current is selectable (up to 40 μA).
- ◎ Gold target (1 μm). Effective energy 5-20 keV.
- ◎ Spherical dose distribution $\sim 2.5 \text{ Gy/min}$ at 10 mm.



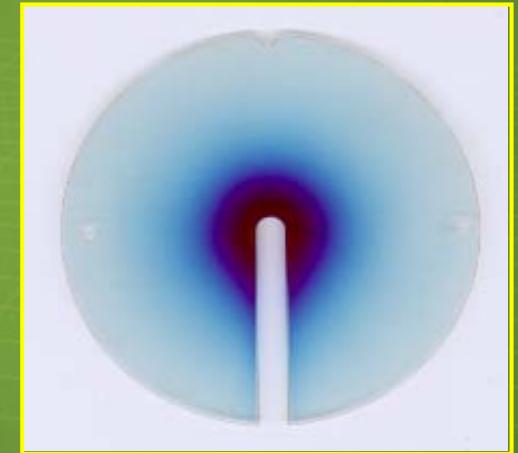
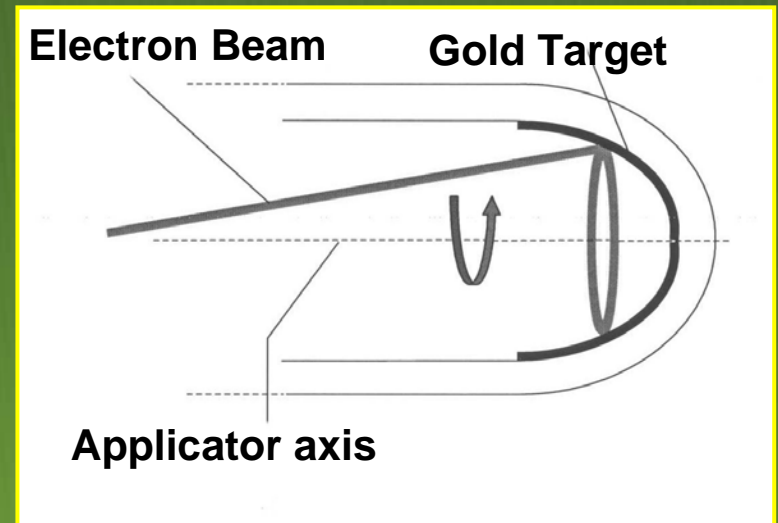
Field Distribution

Electron beam is 'dithered' about gold target.

Through process of Bremsstrahlung, photons are produced.

These have a spherical distribution.

Applicators are used as 'spacers' and tumour bed is physically conformed to its surface, ensuring even dose distribution.



Applied to Breast Cancer

Tumour surgically removed with wide local excision (WLE)

Haemostasis.

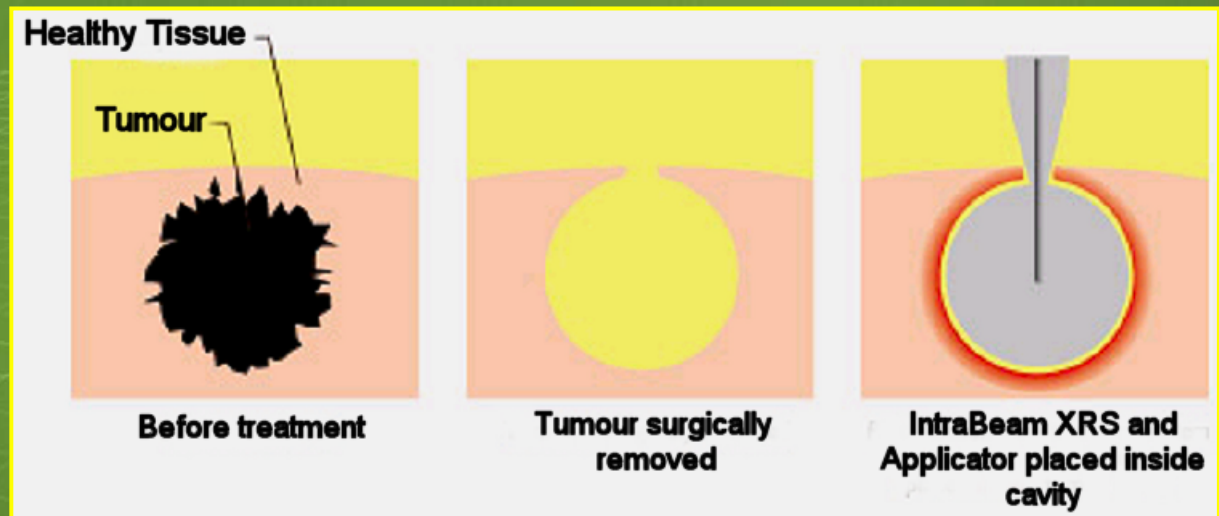
Cavity measured, applicator chosen.

Treatment time depends on applicator size.

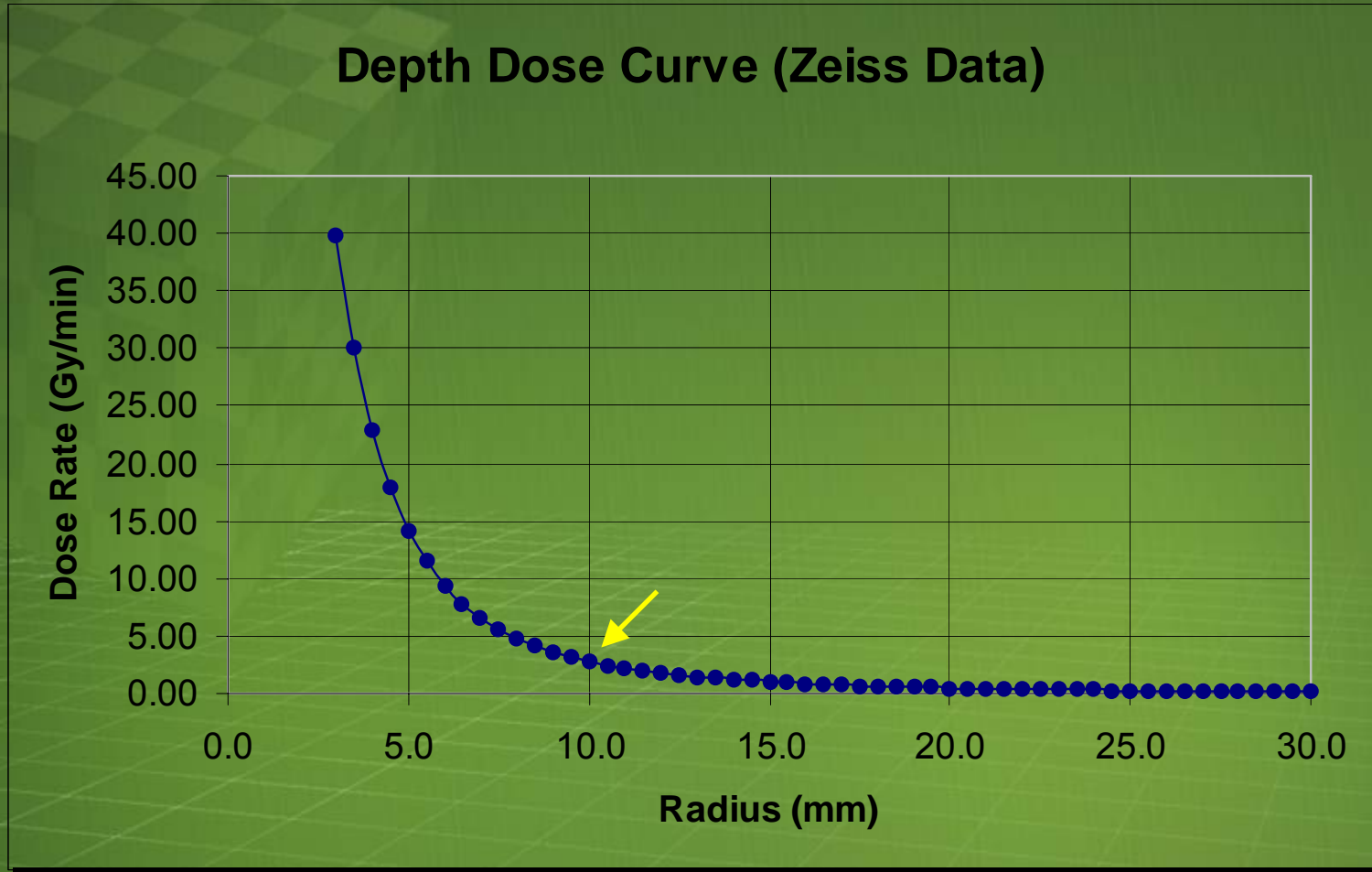
Size \propto Treatment Time

Mean time approx.

28 mins.



Operating Principle



Treatment Details - Breast

No.	Applicator (cm)	Breast Site	Intent	Age	Dose @ 1 cm in (Gy)	IORT time (min)	Cumm Photon Cnt	Average Photon Cnt
26	4.5	L	Radical	53	5.0	26.91	150700000	5600149
27	4.5	L	Radical	73	5.0	28.77	139100000	4834897
28	3.5	L	Radical	70	5.0	18.46	89400000	4842904
29	4.5	R	Radical	47	5.0	29.28	139600000	4767760
30	4.5	R	Radical	51	5.0	29.79	139800000	4692850
31	3.5	R	Radical	64	5.0	16.81	94700000	5633551
32	5.0	R	Radical	67	5.0	32.53	184200000	5662465
33	4.5	L	Radical	63	5.0	26.74	150300000	5620793
34	3.5	L	Radical	69	5.0	16.98	73600000	4334511
35	4.5	R	Radical	65	5.0	26.49	115200000	4348811
36	4.0	L	Radical	69	5.0	21.73	94300000	4339623
37	5.0	L	Radical	70	5.0	33.11	182500000	5511930
38	4.5	L	Radical	63	5.0	26.65	151000000	5666041
39	4.5	R	Radical	55	5.0	26.58	149700000	5632054
40	4.0	L	Radical	48	5.0	21.13	91700000	4339801
41	4.5	L	Radical	50	5.0	26.53	114700000	4323407
42	3.5	L	Radical	53	5.0	18.56	82000000	4418103
43	5.0	R	Radical	68	5.0	34.81	153100000	4398161
44	4.0	R	Radical	72	5.0	22.38	99200000	4432529
45	5.0	R	Radical	62	5.0	33.17	184400000	5559240
46	5.0	R	Radical	75	5.0	33.25	184500000	5548872

	IORT time (min)	Cumm Photon Cnt	Average Photon Cnt
Mean	28.54	136806087	4964165
SD	5.96	30432493	610634
95% C.I.	1.72	8794397	176461
LCL	26.82	128011690	4787704
UCL	30.26	145600484	5140627
Median	29.07	143950000	4801329
Min	16.79	73600000	4316426
Max	36.46	184500000	5666041

Applicator Size (cm)	Times Used
3.0	1
3.5	5
4.0	8
4.5	16
5.0	16
Total:	46



Treatment Details - Brain

No.	Applicator (cm)	Brain Site	Intent	Age	IORT Dose @ 0.5 cm in (Gy)	IORT time (min)	Cumm Photon Cnt	Average Photon Cnt
1	1.5	R	Palliative	48	15.0	15.60	75600000	4845843
2	2.5	L	Radical	71	12.0	23.98	116300000	4849673
3	3.0	L	Radical	68	8.0	20.62	100600000	4879705
4	2.0	L	Radical	69	12.0	17.39	83800000	4818584
5	2.0	L	Palliative	55	12.0	17.28	84190000	4871543
6	3.0	R	Palliative	82	8.0	20.92	101400000	4846110
7	2.5	R	Palliative	53	12.0	24.45	117000000	4784885
8	1.5	R	Radical	64	15.0	15.07	73370000	4868290
9	2.5	L	Palliative	56	8.0	16.10	77560000	4817691
10	3.5	R	Palliative	61	10.0	21.39	104100000	4866760
11	2.5	R	Palliative	64	15.0	29.04	141100000	4858648
12	3.5	R	Radical	57	8.0	17.86	84890000	4752281
13	2.0	R	Radical	73	15.0	22.02	106500000	4836512
14	3.0	L	Radical	37	8.0	19.83	85800000	4326778
15	3.0	L	Palliative	74	8.0	19.70	85300000	4329949
16	2.0	R	Radical	44	12.0	16.33	71050000	4350888
17	3.0	L	Radical	64	8.0	19.68	84800000	4308943
18	3.5	R	Radical	32	10.0	22.11	98100000	4436906
19	1.5	R	Palliative	60	12.0	12.47	60000000	4811548
20	2.5	L	Radical	68	12.0	22.05	124100000	5628118

	IORT time (min)	Cumm Photon Cnt	Average Photon Cnt
Mean	19.70	93778000	4754483
SD	3.84	20197818	299057
95% C.I.	1.68	8851908	131065
LCL	18.01	84926092	4623418
UCL	21.38	102629908	4885547
Median	19.77	85550000	4827548
Min	12.47	60000000	4308943
Max	29.04	141100000	5628118

Applicator Size (cm)	Times Used
1.5	2
2.0	4
2.5	6
3.0	5
3.5	3
Total:	20

Summary

- ◎ IORT using low kV x-rays is a viable alternative to external beam radiotherapy.
- ◎ Treatment tolerated well by most patients. No seriously adverse side-effects to date.
- ◎ Very reasonable set-up costs compared with EBRT.
- ◎ Single procedure for the patient.

Manufacturer

Philip Peacock

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www.medicalphysicist.co.uk