Intra-operative Radiation Therapy (IORT) Zeiss Intrabeam®

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21st Century Oncology
• Radical Mastectomy
• Modified Radical Mastectomy
• Lumpectomy + Axillary Node Dissection + Radiotherapy
• Lumpectomy + Sentinel Lymph Nodes + Radiotherapy
• Lumpectomy + Sentinel Lymph Nodes + Partial Breast Radiotherapy
• Lumpectomy + Sentinel Lymph Nodes + IORT ± Radiotherapy
• Future?
IORT Advantages

- Time
- Effectiveness
- Precision
- Lower Complications
  - Cardiac
  - Pulmonary
  - Second Malignancies
- Less Shielding Requirements
IORT

- 20 Gy in one fraction
- As boost or Alone
  - According to the TARGIT trial can be used alone if
    - Greater than 50 years old
    - 3cm or less and well differentiated
    - ER+, PR+, and Her2-
    - Node negative invasive ductal carcinoma
      - Any of these Features not present it can only be used as a boost
- Less Expensive
IORT

• As Effective
  – Ultimate APBI
  – Over 90% of local recurrences occur near the original tumor

• More Effective?
  – Greater Biological Effect
    • Any very high dose (10-20Gy) in one fraction is more effective at killing cells than fractionation
  – Avoids Repopulation
    • Eliminates tumor cells which decreases the load of tumor cells during wound healing
**What is it?**
- A complete system to deliver Intra-operative, or post-operative RT directly into tumors, or tumor cavities.

**What does it do?**
- Generates and delivers a high dose of low energy (50KeV) x-rays in a precise, spherical distribution pattern around a point source.
What are the Components?

- XRS/PRS (Control Console)
- Support Stand
- Applicators (solid, balloons)
- Disposables (external shields and drapes)
Zeiss Intrabeam®

- 50 kV x-ray source at the end of a 15 cm long, 3.5 mm diameter tube.

- Spherical applicators with diameters of 15-50 mm in steps of 5 mm

- Dose rate of about 2 Gy/min at 1 cm in water
Intrabeam Components

XRS: A miniature x-ray source.
The INTRABEAM radiation source accelerates electrons with a maximum voltage of 50 kV onto a gold target. It is here that the low-energy X-ray radiation is generated and then emitted.
Internal Radiation Delivery

A steep dose fall-off ensures that most of the dose stays in the target tissue. Spherical dose delivery helps ensure radiation is delivered safely and reliably to tumors and tumor beds. Minimal shielding requirements mean safety for the patient and personnel.
Figure 4. The physical X-ray dose at various distances in a breast phantom for the typical applicator of 3.5 cm diameter and a prescription of 5 Gy at 1 cm.
The position of the Tumor Is Determined
The Tumor Is surgically Removed
The applicator tip is positioned in the area of the breast where the tumor was located.
Treatment Workflow

1) QA procedure must be performed within 36hrs of each treatment.
2) Lumpectomy procedure
3) Assess the cavity size and select the proper applicator
4) XRS probe and the Intrabeam stand are covered in a sterile polyethylene bag
6) Secure the applicator to the XRS probe
7) Position the applicator in the lumpectomy cavity
Intrabeam Components What does each do?

**PRS 500 Control Console:**
Connects the XRS with 12v cable and is used to set all the operating parameters: accelerating voltage, beam current, and treatment time.

- **Quality Assurance**
- **Prescription Planning**
- **Treatment Monitoring**
- **Treatment Verification Documentation**
PDA (Photodiode Array)

- Contains five photodiodes at orthogonal positions
- Verifies the isotropy of the X-ray beam emitted from the probe tip.
- Steering of the beam based on the five photodiode readings
- Align the electron beam with the center of the probe
Quality Assurance

PAICH (Probe adjuster/Mount for ion Chamber ionization chamber holder)

• Measures and adjusts the straightness of the probe manually

• Inbuilt temperature/pressure correction
Intrabeam Components
What does each do?

**Intrabeam Stand**

- A balanced, mobile stand to allow for six degrees of freedom using electromagnetic clutches and breaking systems to ensure safe and accurate delivery of the probe to the target.

- The Intrabeam may be rolled into any O.R. suite and no special room shielding is required.
Intrabeam Components
What does each do?

Intrabeam Applicators

- Spherical Applicator Set Ranges from 1.5 to 5.0 cm diameters are available.
- Ideally used in intracavitary applications to “fill” the tumor bed, which ensures an equal and spherical dose distribution to the surrounding tissue.
- The tissue is physically conformed to the dose VS. the dose being conformed to the tissue.
Intraoperative RT

Figure 2. The applicator being placed in the tumour bed, immediately after the excision of the tumour.
Applicator Type
Choose Applicator Size
Enter Patient Data
Choose Location (coordinates)
Enter Prescription

- **XRS**: No. 000347, Name: 2nd XRS 50
- **Voltage**: 50 [kV]
- **Current**: 40 [μA]
- **Applicator Type**: Spherical
- **Size**: 4.0 [cm]
- **No.**: 338809
- **Patient Information**:
  - **Patient ID**: 134501-2006
  - **Treatment #**: 37

- **Prescription Dose**: 20.00 [Gy]
- **Treatment Depth**: 0.00 mm from Surface
- **Treatment Time**: 0:24:11 [h:m:s]
- **Dose Rate at Depth**: 0.827 [Gy/min]

**Graph**
- Depth [mm] vs. Dose [Gy]
  - Depth in mm from Surface
  - Dose in Gy
PAICH 2nd Output Check

<table>
<thead>
<tr>
<th>Calibration ((N_K))</th>
<th>(1.125 \times 10^9 \text{ Gy} / \text{A sec})</th>
<th>Date: ______________</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dosimeter Reading ((\text{pA}))</td>
<td>54.04</td>
<td></td>
</tr>
<tr>
<td>P &amp; T Correction Factor</td>
<td>1.008</td>
<td></td>
</tr>
</tbody>
</table>

\[
N_K \quad \quad \quad \quad \text{DR} \quad \quad \quad \text{Time} \quad \quad \quad C_{TP}
\]

Dose Rate = \((1.125 \times 10^9 \text{ Gy} / \text{A sec}) \times (54.04 \times 10^{-11} \text{ A}) \times (60 \text{ sec} / \text{min}) \times (1.008)\)

Dose Rate = 3.677 GY / min

PAICH Output Dose Rate \((\text{Gy} / \text{min})\) = 3.6780 Gy / min

Difference = >0.1 %
Intrabeam 2nd Check

Patient Name: 
MR#: 
Date: 

Run Time = \( \frac{D_{px}}{D_0 \times IC_{ratio} \times ATF} \) min

- \( D_{px} \) = Prescribed Dose (Gy)
- \( D_0 \) = Dose Rate in Water (Gy/min)
- \( IC_{ratio} \) = Ion Chamber Ratio
- \( ATF \) = Application Transfer Function (Attenuation + Scatter)

Time = \( \frac{20GY}{Gy/min \times 1.0 \times 1.0} \) min

Time = min min sec

Actual Treatment Time = min min sec

Difference = %
<table>
<thead>
<tr>
<th>POINT</th>
<th>LOCATION</th>
<th>DOSE RATE (mR/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• (A)</td>
<td>RT Doorway Entrance</td>
<td>0.06</td>
</tr>
<tr>
<td>• (B)</td>
<td>Doorway Entrance</td>
<td>0.05</td>
</tr>
<tr>
<td>• (C)</td>
<td>LT Doorway Entrance</td>
<td>0.04</td>
</tr>
<tr>
<td>• (D)</td>
<td>Sub Sterile Room</td>
<td>0.06</td>
</tr>
<tr>
<td>• (E)</td>
<td>Hallway</td>
<td>0.06</td>
</tr>
<tr>
<td>• (F)</td>
<td>Scrub Doorway Entrance</td>
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</tr>
<tr>
<td>• (G)</td>
<td>Wall; Scrub area</td>
<td>0.04</td>
</tr>
<tr>
<td>• (H)</td>
<td>Wall; Scrub area</td>
<td>0.03</td>
</tr>
<tr>
<td>• (I)</td>
<td>Wall; Storage Area</td>
<td>0.03</td>
</tr>
<tr>
<td>• (J)</td>
<td>Wall; Storage Area</td>
<td>0.03</td>
</tr>
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</table>
Conclusions

- IORT is the latest advance in the treatment of breast cancer congruent with the shared goals of
  - Minimizing Invasiveness
  - Minimizing Unnecessary Exposure
  - Minimizing Patient Discomfort
  - Maximizing Efficiency
  - Maximizing Precision
  - Maximizing Cancer Control
  - Maximizing Cosmesis