ACCELERATED PARTIAL BREAST IRRADIATION: INTERSTITIAL IMPLANTS

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The entire breast does not need to be irradiated in all patients.

Intensifying radiotherapy to the tissue at greatest risk for subclinical disease may reduce local recurrence rates.
Prescription Dose

40-34 Gy in 8-10 fractions twice daily over 4-5 days with BED of 45 Gy ($\alpha/\beta = 10$)
From 11/2000 – 37/2005:

Total of 280 patients have been treated with definitive wide volume breast brachytherapy.

254 patients have been treated with interstitial brachytherapy.

26 patients have been treated with mammosite (intracavitary).
Traditional Tools

- Brachytherapy - Surgical Art - Prior knowledge of location and volume of target needed for implant

- Dosimetry based on orthogonal films for source localization incorporating very large random errors inherent in conventional treatment evaluation.
Applicator Placement Techniques

- **Interstitial:**
  - Template-guided prone approach; uses a stereotactic core biopsy table with digital mammographic guidance
  - Free-hand supine approach; uses ultrasound guidance
Prone Patient Position
Template-guided prone approach
Target Volume Definition

Target Volume

Lumpectomy cavity/surgical clips + 2-cm margin
Schematics of Template
Free-hand supine approach
## Comparison of Techniques

<table>
<thead>
<tr>
<th></th>
<th>Supine/Ultrasound</th>
<th>Prone/Digital Mammogram</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgical Art</td>
<td>Operator Dependent</td>
<td>Template/Operator Independent</td>
</tr>
<tr>
<td>Less Number of Catheters</td>
<td></td>
<td>More Number of Catheters</td>
</tr>
<tr>
<td>Irradiation Time</td>
<td>Same</td>
<td>Irradiation Time Same</td>
</tr>
<tr>
<td>Less Simulation/Planning Time</td>
<td></td>
<td>More Simulation/Planning Time</td>
</tr>
<tr>
<td>Less Treatment Time</td>
<td></td>
<td>More Treatment Time</td>
</tr>
</tbody>
</table>
- Patient Supine

- Patient Prone
Breast Brachytherapy
Target Volume

1 cm
Target Volume

2 cm
Biopsy Cavity
### Dosimetric Comparison

<table>
<thead>
<tr>
<th></th>
<th>2D Treatment Planning</th>
<th>3D Treatment Planning</th>
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</thead>
<tbody>
<tr>
<td>$R_x$</td>
<td>400 cGy</td>
<td>400 cGy</td>
</tr>
<tr>
<td>Target Volume</td>
<td>70 cc</td>
<td>70 cc</td>
</tr>
<tr>
<td>Total catheters used</td>
<td>21</td>
<td>16</td>
</tr>
<tr>
<td>Target volume covered</td>
<td>87%</td>
<td>94%</td>
</tr>
<tr>
<td>Total volume by 50%</td>
<td>403 cc</td>
<td>252 cc</td>
</tr>
<tr>
<td>Total volume by 100%</td>
<td>140 cc</td>
<td>103 cc</td>
</tr>
<tr>
<td>Total volume by 150%</td>
<td>27 cc</td>
<td>30 cc</td>
</tr>
<tr>
<td>Dose Homogeneity Index</td>
<td>0.81</td>
<td>0.71</td>
</tr>
</tbody>
</table>
Patient Treatment Position
Comfort Catheter system
Quality Assurance

- Manual Verification of HDR Computer Calculations
<table>
<thead>
<tr>
<th>Vol (cm³)</th>
<th>mRaEqhr /1000R*</th>
<th>Rᵥ (Cis/Gy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>463</td>
<td>314</td>
</tr>
<tr>
<td>80</td>
<td>633</td>
<td>429</td>
</tr>
<tr>
<td>100</td>
<td>735</td>
<td>498</td>
</tr>
<tr>
<td>140</td>
<td>920</td>
<td>624</td>
</tr>
<tr>
<td>180</td>
<td>1087</td>
<td>737</td>
</tr>
<tr>
<td>220</td>
<td>1243</td>
<td>843</td>
</tr>
<tr>
<td>300</td>
<td>1529</td>
<td>1037</td>
</tr>
<tr>
<td>340</td>
<td>1662</td>
<td>1127</td>
</tr>
<tr>
<td>380</td>
<td>1788</td>
<td>1212</td>
</tr>
</tbody>
</table>

* Parker: A dosage system for interstitial Radium Therapy
BJ R:11:313-339, 1938

<table>
<thead>
<tr>
<th>Elongation Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length/Diameter</td>
</tr>
<tr>
<td>1.5</td>
</tr>
<tr>
<td>2.0</td>
</tr>
<tr>
<td>2.5</td>
</tr>
<tr>
<td>3.0</td>
</tr>
</tbody>
</table>
Total Time for volume implants

\[
\text{Time} = \frac{\text{Reference Dose (Gy)} \times R_v \times \text{Elongation Factor}}{\text{Activity (Ci)}}
\]
Figure 1

- $R_v$, this study
- $R_v^2$, Original Manchester
- volume implant table
- corrected for modern units

Volume (cm$^3$) vs. $R_v$ (Ci.s.Gy)
Characteristics of Interstitial Implants
Quantitative Analysis of Brachytherapy Implants

- Percent Target Volume Coverage. The 100% isodose (Rx) line should cover the whole target.
- Goal 100%.
3D CT Planning

Dose Volume Histogram
(Integral)

Volume [%]  # of points: 100000
Max. Dose [cGy]: 1200

Dose displayed:
Brachy total dose in water

<table>
<thead>
<tr>
<th>VOI</th>
<th>Vol. Area (cc)</th>
<th>Dose (cGy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>target</td>
<td>70.1</td>
<td>48 4705 227 598</td>
</tr>
</tbody>
</table>

dose: 400
target: 94.0
Quantitative Analysis of Interstitial Implants

- Dose Homogeneity Index (DHI)

\[
\text{DHI} = \frac{V_{100} - V_{150}}{V_{100}}
\]

- Ideal: DHI = 1.0
Quantitative Analysis of Interstitial Implants

- Ratio of Target Volume to $V_{100}$

\[
\frac{\text{Target Volume}}{\text{Volume of 100\% isodoseline}}
\]

- Ideal: 1.0
Dosimetric comparison of interstitial and mammosite APBI
Percentage PTV coverage

Percentage of Patients

Interstitial (N = 50)
Mammosite (N = 20)

Percentage PTV Coverage

< 80%  80% - 85%  85% - 90%  90% - 95%  95% - 100%
Dose Homogeneity Index (DHI)

Percentage of Patients

- Interstitial (N = 50)
- Mammosite (N = 20)

Dose Homogeneity Index

- 0.40 - 0.49
- 0.50 - 0.59
- 0.60 - 0.69
- 0.70 - 0.79
- 0.80 - 0.89
Institutional dosimetric comparison of APBIs
<table>
<thead>
<tr>
<th></th>
<th>V100 (cm³)</th>
<th>V150 (cm³)</th>
<th>PTV (cm³)</th>
<th>% PTV coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>This study</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Mammosite</td>
<td>74</td>
<td>21</td>
<td>86</td>
<td>86</td>
</tr>
<tr>
<td>Interstitial</td>
<td>226</td>
<td>59</td>
<td>182</td>
<td>95</td>
</tr>
<tr>
<td><strong>WBG</strong></td>
<td>87</td>
<td>20</td>
<td>81</td>
<td>76</td>
</tr>
<tr>
<td></td>
<td>186</td>
<td>24</td>
<td>105</td>
<td>58</td>
</tr>
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</table>
Image guided breast brachytherapy challenges the notion that the entire breast needs to be irradiated...
…and offers an attractive alternative to 6 weeks of daily external beam radiation therapy for a heterogeneous population of women with early stage breast cancer.
Acknowledgments

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