Comparative dosimetry study of three UK centres implementation of Total Skin Electron Treatment (TSEBT) through external audit

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Overview

- TSEBT at Guy’s and St Thomas’ Hospital (GSTT)
- Modified Stanford technique
- Audit Method
  - Beam Dosimetry
  - Clinical Simulations
- Results
- Conclusions
TSEBT at GSTT

- Mainly for treatment of Mycosis Fungoides
- Over 100 patients treated since 2006
- Typical Fractionation:
  - 6MeV High dose rate
  - 30 Gy in 20#s, 4 days per week over 5 weeks
- In-vivo monitoring – 1st # with TLD’s
- Daily QC performed with Diodes
TSEBT at GSTT

Dummy Applicator
Modified Stanford technique
Modified Stanford technique
### Techniques at Centres A and B

<table>
<thead>
<tr>
<th>Centre</th>
<th>Nominal Beam energy (MeV)</th>
<th>Perspex Degrader Location</th>
<th>Treatment distance</th>
<th>Dual beam treatment angles (Hinge angle)</th>
<th>Dose per Fraction (cGy)</th>
<th>MU delivered per field</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSTT</td>
<td>6</td>
<td>At patient</td>
<td>350</td>
<td>72.5 and 107.5 (35°)</td>
<td>150</td>
<td>93</td>
</tr>
<tr>
<td>Centre A</td>
<td>6</td>
<td>At patient</td>
<td>400</td>
<td>288 and 253 (35°)</td>
<td>200</td>
<td>157</td>
</tr>
<tr>
<td>Centre B</td>
<td>6</td>
<td>In treatment head</td>
<td>400</td>
<td>70 and 110 (40°)</td>
<td>150</td>
<td>120</td>
</tr>
</tbody>
</table>
Audit Method – Beam Dosimetry

- Minimal guidance on audits for TSEBT
- Tests performed based on QC at GSTT

highlighted below

<table>
<thead>
<tr>
<th></th>
<th>Monthly</th>
<th>Quarterly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam Monitoring</td>
<td>Beam Running parameters and basic interlocks</td>
<td>As monthly</td>
</tr>
<tr>
<td>Standard Distance (95cm SSD)</td>
<td>Output and energy</td>
<td>Energy, Flatness and Symmetry</td>
</tr>
<tr>
<td>Extended Distance (350cm SSD)</td>
<td>Not performed</td>
<td>Single and Dual Field output and Energy</td>
</tr>
<tr>
<td>Diodes</td>
<td>Daily QC performed</td>
<td>Calibration check Flatness and Symmetry, Daily QC</td>
</tr>
</tbody>
</table>
## Audit Method – Beam Dosimetry

<table>
<thead>
<tr>
<th></th>
<th>Standard Distance (95 or 100cm SSD)</th>
<th>Extended distance (350 or 400cm SSD)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Output and Energy Check</strong></td>
<td><strong>Output</strong> – NACP chamber, Wte at $d_{max}$ Gantry 0°. 100MU.</td>
<td><strong>Output</strong> – Wte at $d_{max}$ for single and dual beams. and 100MU.</td>
</tr>
<tr>
<td></td>
<td><strong>Energy</strong> – ratio at two different depths.</td>
<td><strong>Energy</strong> – as standard distance.</td>
</tr>
<tr>
<td><strong>Flatness and Symmetry</strong></td>
<td><strong>Flatness</strong> – Average of TGAB at 12cm <strong>Symmetry</strong> – Ratio of 12cm points in TG and AB.</td>
<td>Not assessed inferred from clinical simulations.</td>
</tr>
</tbody>
</table>
Clinical Simulation

- Clinical Simulation performed using centre’s Rando Phantom.
- Rando phantom placed on a custom support stool allowing 60 degree rotations for treatment positions.
- EBT2 Gafchromic film cut to shape and placed transverse in pelvic region.
- Gafchromic film calibrated at 6MeV and readout out at GSTT using an EPSON Flatbed scanner and PTW Verisoft v3.1 and subsequently normalised to the dose per fraction.
Clinical Simulation

- TLD’s were placed in the head and thorax region corresponding to the positions used clinically at GSTT.
- TLD’s were calibrated in a 6MeV beam at $d_{\text{max}}$ in the Centre’s beam.
- TLD’s readout at GSTT using a Harshaw 5500 TLD reader.
- The average trunk dose was determined from the TLD readings.
- Beams delivered as per treatment through MOSAIQ.
Dosimetric Considerations

- Polarity effect and Stem leakage overcome through cable shielding with lead (2mm)
- Ion recombination at standard distances is significant
  - At GSTT cGy/MU calibrated using 6MeV calibration factor and additional $p_{ion}$ of 1.015 to 1.018
## Results – Beam Dosimetry

<table>
<thead>
<tr>
<th>Beam Dosimetry</th>
<th>Standard Distance (95 or 100cm SSD)</th>
<th>Single / Dual field at treatment distance</th>
<th>Clinical Simulation TLD results</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Output (cGy/MU)</td>
<td>Energy ratio</td>
<td>Flatness (% ave TGAB)</td>
</tr>
<tr>
<td>Centre A</td>
<td>10.98</td>
<td>0.650</td>
<td>98.1</td>
</tr>
<tr>
<td>Centre B</td>
<td>12.69</td>
<td>0.529</td>
<td>85.0</td>
</tr>
<tr>
<td>Expected values</td>
<td>10.0</td>
<td>0.405</td>
<td>98.5</td>
</tr>
</tbody>
</table>

**Centre**: Centre A and Centre B are the locations with the results presented. The expected values are given for comparison.

**Output**: The output is measured in cGy/MU.

**Energy ratio**: The energy ratio is a measure of how the energy of the beam changes with distance.

**Flatness (% ave TGAB)**: Flatness measures the uniformity of the dose distribution across the field.

**Symmetry (%)**: Symmetry measures the uniformity of the dose distribution along the central axis.

**Output (cGy/MU)**: The output for single (S) and dual (D) fields at different SSDs.

**Energy ratio**: The energy ratio for single (S) and dual (D) fields.

**Dose per # (cGy)**: The dose delivered per treatment field.

**Average Trunk Dose (cGy)**: The average dose delivered to the trunk.
Results – Beam Dosimetry

- Standard SSD
  - Beam output varied depending on calibration methods and position of degrader
  - Overall Flatness lower at Centre B 85% compared to Centre A due to position of degrader
  - Beam symmetry at both centres within ±1.0% in TG and AB.
Results – Beam Dosimetry and TLD

- Extended SSD
  - Single and dual output measurements agreed within 1.0% at centre A and 1.5% at centre B

- TLD Trunk Dose
  - Average trunk dose at Centre A within -1.6%
  - Average trunk dose at Centre B within -6.7%
  - Variation in TLD readings between sites:
    - Centre A 196.8cGy ± 13.6cGy (6.9%)
    - Centre B 139.9cGy ± 5.1cGy (3.6%)
    - Clinical GSTT results to date 148.7cGy ± 12.2cGy (8.2%)
Results – Clinical Simulation

(a) Centre A

(b) Centre B
Results – Clinical Simulation

(a) Centre A

(b) Centre B

(c) GSTT
Results – Clinical Simulation

- General isodose shape similar between GSTT and centres A and B
- All distributions met EORTC requirements of 80% at ≥ 4mm and 20% at ≤ 20mm
- All exhibited a lower dose region laterally where 80% comes closer to the surface
- To be expected with no lateral beams
Conclusions

- HDRE beam dosimetry at centre A and B were acceptable at the standard and extended treatment distances.

- TLD results showed the average trunk dose was within 2.0% of expected at centre A and -6.7% at centre B.

- Gafchromic film results showed that GSTT and centres A and B comply with the EORTC recommendations [3].
References


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Any Questions?
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