A comparison of the relative biological effectiveness of low energy brachytherapy source in breast tissue: A Monte Carlo study.

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Conflict of interest

This work was supported by Xoft®
Introduction

- Purpose
- Background
  - RBE
  - LET
  - DNA damage
- Workflow
- Electron spectrum
- RBE
- Conclusion
Purpose

Average energy difference vary by 1.7 keV or 5.6% for 50kV operating voltage

Do subtle spectral differences influence RBE?
Relative Biological Effectiveness (RBE)

“Inverse ratio of the amount of radiation required to produce a given effect compared to a reference radiation producing the same effect”

Complex quantity determined by:

- Radiation dose
- No. of fractions
- Dose rate
- Biological system or endpoint
- Radiation quality (Linear energy transfer)
Linear energy transfer in EBS

Lower electron energy >>> greater LET >>> More DNA damage
DNA damage

Single Strand Break (SSB)

Double Strand Break (DSB)

Low – LET particle

High – LET particle
DNA Damage (II)

- From Semenenko and Stewart, 2006
Purpose:

Average energy differences due to choice of material in anode,

Gold (Intrabeam) vs. Tungsten (Xoft)
Tissue Geometry

Electron spectra calculated at edge of sphere using EGSnrc
Workflow

Tissue Geometry

Monte Carlo Electron spectra Calculation

GEANT4
EGSNRC
COMPTON SCATTER

Generates electrons with high LET (0.1 – 6keV)

- High energy photon
- Bound electron
- Free electron
- Vacancy

V

Vacancy

L-
Shell

K-Shell

L-Shell

Lp-Shell
PHOTOELECTRIC ABSORPTION

- High energy photon
- Bound electron
- Vacancy

K-Shell
L-Shell
Lp-Shell
PHOTOELECTRIC ABSORPTION

- High energy photon
- Bound electron
- Free electron
- Vacancy

Generates electrons with lower LET (10 – 50 keV)
AUGER ABSORPTION

- High energy photon
- Bound electron
- Free electron
- Vacancy

Generates electrons with highest LET (0.2 – 1keV)
Electron spectra

Zeiss vs. Xoft: electron spectra 10mm

Compton electrons

Photo-electrons

Energy (keV)
Electron spectra

- Auger Electrons (peaks at 0.5keV)
- Compton electrons
- Photo-electrons
Workflow

Tissue Geometry → Monte Carlo Electron spectra Calculation → DNA damage Calculation DSB → RBE

Reference

DNA damage Calculation: Cobalt-60

\[ \text{RBE} = \frac{(\text{Strand break yield})}{(\text{Strand break yield})_{\text{Reference}}} \]
### RBE: Results

<table>
<thead>
<tr>
<th>Distance from surface (mm)</th>
<th>Source type</th>
<th>Gland $\text{RBE}_{(DSB)}$</th>
<th>Adipose $\text{RBE}_{(DSB)}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Axxent</td>
<td>1.50</td>
<td>1.54</td>
</tr>
<tr>
<td></td>
<td>Intrabeam</td>
<td>1.50</td>
<td>1.55</td>
</tr>
</tbody>
</table>

- **Source type**: Axxent, Intrabeam
- **Distance from surface (mm)**: 0
- **Table columns**: Gland $\text{RBE}_{(DSB)}$, Adipose $\text{RBE}_{(DSB)}$
- **Table values**: 1.50, 1.54, 1.50, 1.55

![Diagram](image)
RBE: mapping
Reduction in kVp produces no significant difference in $RBE_{DSB}$ ($RBE \approx 1.5$)
Conclusions

Zeiss Intrabeam and Xoft Axxent demonstrate similar $RBE_{DSB}$ at all depths and tissues calculated ($RBE \approx 1.5$)

Radiation Quality plateau between 30 and 50kVp.