Electron Conformal Therapy

Using Custom Bolus to conform Electron Beam Therapy

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Historical Progression of RT

• Photon Therapy

Linear Accelerator (non-clinical) → Colbalt-60 → Linear Accelerator

Field Modulation
2D Treatment Planning
2.5D Treatment Planning
3D Treatment Planning
IMRT
VMAT

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Historical Progression of RT

• Superficial Therapy

Grenz → Superficial → Orthovoltage

Electrons

Field Modulation
2D Treatment Planning
3D Treatment Planning
Measuring Cutouts
MU Calculations: TPS or Measured
Reason for advancement of Photons....

Answer: Patient population – many more deep seated tumors treated with RT.

Numbers of peripheral tumors vs. superficial tumors determined the market.

It’s time for the electron to catch up!!!!
Electron Beam Therapy

• Interactions
  – Inelastic collisions with atomic electrons
    • Ionization and excitation (low atomic number media)
  – Inelastic collisions with nuclei
    • Bremsstrahlung (higher atomic number materials such as lead)
  – Elastic collisions with atomic electrons
  – Elastic collisions with nuclei
Electron Beam Therapy

• Electron Scattering
  – Coulomb force interactions
  – Acquire velocity components
  – Displace from original direction of motion
Surface Dose

- Lower energies scatter more easily and through larger angles

![Diagram showing the difference between low energy and high energy surface dose]

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Isodose Curves

• Central Axis Distributions, Flatness, and Curvature near field borders
  - Collimations Systems
  - Air Gaps (between cone and patient)
  - Obliquity
  - Energy
  - Field Size
  - Cone Size
  - Cutouts
Isodose Curves

Surface Irregularities
Isodose Curves

InHomogeneities

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Solutions (Bolus)

- Paraffin Wax
- Polystyrene
- Lucite (Spoilers)
- Superstuff
- Superflab
- Brass mesh
- Rice Bags
- Wet Guaze
- Water

Custom Uniform Thickness

Custom Conformal Thickness

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Where are Electron Treatments?

• What is happening in clinics today???
• Fabrication of own Electron cutouts and Bolus
Where are Electron Treatments?

- Electrons are still being calculated by hand
Issues in current processes

- Clinics fabricate their own “handmade” beam modifications devices, which leads to:
  - Variability (from what was planned)
  - Imperfections in fabrication
  - Limitations in machining
Issues in current processes

• Issues with Bolus
  – Air Gaps
  – Rarely custom tailored to patient
  – Sanitation (often re-used on different patients...gross!)
  – Potential for error in bolus placement, and bolus selection .3cm vs .5cm vs 1cm
Issues in current processes

• Electron Planning Issues
  – Relatively few factors that can be controlled
  – Dose Heterogeneity
  – Energy Selection
  – May cover PTV geometrically but dose distribution may be inadequate due to variable PTV depths
Issues in current processes

• Sparing underlying critical structures
So What’s Next for Electrons?

• Electron Therapy advancements have essentially “sat on a shelf” for years

• Even though electron calculation models have improved, developments in delivery have sat idle
So What’s Next for Electrons?

• Possible Answer......Electron Conformal Bolus with a custom milled block...
What is it?

- A custom milled device that allows the use of a **single electron beam** with a variable thickness bolus to shape the distal prescribed isodose line to conform to and contain the PTV...
What is it?
Development

- Developed at MD Anderson in the 90’s
- Well published technique
- Employs single electron field
- Allows user to conform dose
  - Typically 90% isodose line to distal surface of PTV
- Delivers minimal dose to adjacent structures
- Shorter planning / treatment times
Fabrication

_decimal factory

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Fabrication

• Using the data that you generate the manufacturer is able to custom build your bolus using the latest machining techniques.
A total of 18 control points analyzed. 9 of which are distal and 9 are proximal with an allowed tolerance of ±0.0254cm
So lets cut to the chase……

• The big 3 questions (in no particular order):
  1.-How much more work is it?
  2.-How expensive is it?
  3.-Is it really worth it?
Implementation at your site

• Works with your existing equipment. Decimal software is all that is needed.

• Is a specialized treatment and meant to fill a niche for very specific situations.

• Gives you another tool for tailoring treatments to individual needs.
Implementation at your site

- Software configuration with electron data
- Provide treatment depths (Dmax, R90, R85, etc) for various energies
- Installation of software via remote upload
- Windows-based PC / Internet Access
- Software Training
- Via Webex
- Approximately one hour required
Implementation at your site

- Afraid this technology will break your department’s budget.....$$$$
Implementation at your site

- No up front costs for the Software, implementation, training, and yes even on-going support is all provided at no cost. You only pay for the devices you use!!!!
The Planning Process

• The patient is brought in for an initial CT simulation
• Patient is positioned to allow gravity to help keep the bolus in position.
• Physician defines treatment borders
The Planning Process

- Using the CT images the physician defines the target
- Critical structures are contoured
- Create and center the treatment beam around the PTV at an SSD of 105cm
  - Why 105cm SSD? Leave room under electron cone for bolus.
• Some planning considerations
  – Try to ensure that treatment field is perpendicular to treatment site.
  – The bolus generating software uses the external/body contour, it is important to make sure that only patient anatomy is included in this. IE Wires and other patient marking aids should be excluded.
A way to ensure that the scar wire doesn’t effect construction of the Electron Bolus is to perform two scans with/without the wire.
The Planning Process

If Scar Wire is not contoured out of dataset, the high degree of precision from machining could leave a divot in the bolus like this....
The Planning Process

• Patient positioning should allow enough room for the Cone to “clear” and also for the bolus to be supported.
The Planning Process

- The RT Plan, structure set, and CT images are then exported to the P.D planning software.
- Once the appropriate files are in the software, the planning process is a breeze!
The Planning Process

• First the software uses the External Contour to generate the initial Bolus structure.
The Planning Process

- Select: The distal PTV coverage you would like to achieve, the energy you would like to use, at what dose you would like any hotspots to be dampened, along with the margin you would like around the inner border.
The Planning Process

• Next click Generate bolus and watch the software work
  – The software uses an automated marching technique.
  – As the bolus is being generated, the Hogstrom redefinition pencil beam (results closely approximate the eMC) electron model approximates dose.
  – This is an iterative process that will take a few minutes.
The Planning Process (Auto-marching process)

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The Planning Process (Auto-marching process)
Once the Bolus is generated and the isodose levels look to be to a suitable level of homogeneity and conformality, the patient’s structure set is sent back into your TPS.
• More planning considerations

- The .Decimal software will create a body + bolus contour called patient.

- Any air gaps between the bolus and body in this contour should be “cleaned” before the Electron Calculation.
The Planning Process

Air Gaps

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Once in the TPS the original electron plan is calculated using the bolus structure.

- An assigned density will come with the bolus structure
The Planning Process

- Recalculate the plan using the original plan with the new Bolus structure
- When the plan is satisfactory the bolus is ordered using the P.D software.
Planning Process

• The bolus will arrive within 24-72hrs, depending on the shipping option that you select

• When the bolus arrives the patient should be scheduled for a verification simulation
  – This is to ensure that the bolus fits
  – That the patient’s setup is deliverable
  – A CT can be performed to ensure there are no major air gaps on the CT images
Planning Process
Planning Process

- Using the CT images obtained during the 2nd simulation a verification plan can now be run.
Virtual plan and final plan match, bolus is verified and patient is ready for treatment.

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Case Study

- Lt sided Chest wall patient
  - Patient received 50.4Gy in 28fx’s in her initial plan
  - According to RTOG 1005 “Ideally: ≤ 5% of the whole heart should receive ≥ 20 Gy for left-sided breast cancers”, with an acceptable mean dose of <5Gy
Case Study

- Due to difficult anatomy the heart V20 is at 4% after only the initial plan. And the mean dose is already at 4.4Gy
Case Study

• Electron bolus plan is run and compared to a conventional Electron plan using a Plan Quality Metrics software for objective analysis.
## Conventional Boost

### Plan Quality Scoresheet: QUICK RX CHESTWALL [1 Metric(s) Removed]

This is the Plan Quality results spreadsheet for Plan Quality Algorithm: QUICK RX CHESTWALL [1 Metric(s) Removed]. The breakdown of results (metric by metric over all components) are shown in individual rows in the spreadsheet.

**PASS/TAIL: 0 IDEAL, 0 ACCEPTABLE, 4 OUT OF TOLERANCE**

<table>
<thead>
<tr>
<th>Plan Quality Metric Component</th>
<th>Result</th>
<th>Score</th>
<th>Max Score</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>[PTV BOOST EVAL] V[9.0Gy] (%)</td>
<td>87.9707</td>
<td>OUT OF TOLERANCE</td>
<td>Pass if &gt;95</td>
<td>OUT OF TOLERANCE</td>
</tr>
<tr>
<td>[HEART] Mean dose (Gy)</td>
<td>3.0174</td>
<td>OUT OF TOLERANCE</td>
<td>Pass if &lt;1.5</td>
<td>OUT OF TOLERANCE</td>
</tr>
<tr>
<td>[LUNG_L] D[20.0%] (Gy)</td>
<td>6.5956</td>
<td>OUT OF TOLERANCE</td>
<td>Pass if &lt;5</td>
<td>OUT OF TOLERANCE</td>
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<tr>
<td>[PTV BOOST EVAL] Homogeneity Index [10.0Gy]</td>
<td>0.3638</td>
<td>OUT OF TOLERANCE</td>
<td>Pass if &lt;0.2</td>
<td>OUT OF TOLERANCE</td>
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## Plan Quality Scoresheet: QUICK RX CHESTWALL

This is the Plan Quality results spreadsheet for Plan Quality Algorithm: QUICK RX CHESTWALL. The breakdown of results (metric by metric over all components) are shown in individual rows in the spreadsheet.

**PASS/FAIL: 4 IDEAL, 0 ACCEPTABLE, 0 OUT OF TOLERANCE**  
**NOTE: 0.5% Grace in Metric Scoring**

<table>
<thead>
<tr>
<th>Plan Quality Metric Component</th>
<th>Result</th>
<th>Score</th>
<th>Max Score</th>
<th>Performance</th>
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<tbody>
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<td>[HEART] Mean dose (Gy)</td>
<td>1.3921</td>
<td>IDEAL</td>
<td>Pass if &lt;1.5</td>
<td>IDEAL</td>
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<td>3.3472</td>
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<td>0.1841</td>
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<td><strong>4/0/0</strong></td>
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</tbody>
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Conventional Boost
Electron Bolus plan
Conventional Boost
Case Study

• Patient is an elderly female with a recurrent skin lesion on the bridge of her nose.

• Patient is blind in one eye. Obviously critical to minimize dose to other eye to preserve vision.

• Prescription of 60Gy in 30fx’s
Case Study

- As you can see by the pink PTV this was a very challenging Tx site
• Bolus is designed and planned around the eye shield
# Conventional 12Mev Electron Plan

## QUALITY REPORTS

**Plan Quality Scoresheet: QUICK RX Face**

This is the Plan Quality results spreadsheet for Plan Quality Algorithm: QUICK RX face. The breakdown of results (metric-by-metric over all components) are shown in individual rows in the spreadsheet.

**PASS/FAIL: 0 IDEAL, 0 ACCEPTABLE, 5 OUT OF TOLERANCE  NOTE: 0.5% Grace in Metric Scoring**

<table>
<thead>
<tr>
<th>Plan Quality Metric Component</th>
<th>Result</th>
<th>Score</th>
<th>Max Score</th>
<th>Performance</th>
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</thead>
<tbody>
<tr>
<td>[PTV 60] V[54.0Gy] (%)</td>
<td>76.7889</td>
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<td>Pass if &gt;95</td>
<td>OUT OF TOLERANCE</td>
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<tr>
<td>[BODY] Max dose (Gy)</td>
<td>74.8993</td>
<td>OUT OF TOLERANCE</td>
<td>Pass if &lt;69</td>
<td>OUT OF TOLERANCE</td>
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<tr>
<td>[LT EYE] Max dose (Gy)</td>
<td>65.1295</td>
<td>OUT OF TOLERANCE</td>
<td>Pass if &lt;60</td>
<td>OUT OF TOLERANCE</td>
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<tr>
<td>[LT EYE] D[0.03cc] (Gy)</td>
<td>63.6569</td>
<td>OUT OF TOLERANCE</td>
<td>Pass if &lt;54</td>
<td>OUT OF TOLERANCE</td>
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<tr>
<td>[LT OPTIC NERVE] D[0.03cc] (Gy)</td>
<td>46.3288</td>
<td>OUT OF TOLERANCE</td>
<td>Pass if &lt;45</td>
<td>OUT OF TOLERANCE</td>
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<tr>
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<td><strong>5 Metrics</strong></td>
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# 12Mev Electron Bolus plan

## QUALITY REPORTS

**Plan Quality Scoresheet: QUICK RX face**

This is the Plan Quality results spreadsheet for Plan Quality Algorithm: QUICK RX face. The breakdown of results (metric-by-metric over all components) are shown in individual rows in the spreadsheet.

**PASS/FAIL:** 5 IDEAL, 0 ACCEPTABLE, 0 OUT OF TOLERANCE. NOTE: 0.5% Grace in Metric Scoring

<table>
<thead>
<tr>
<th>Plan Quality Metric Component</th>
<th>Result</th>
<th>Score</th>
<th>Max Score</th>
<th>Performance</th>
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</thead>
<tbody>
<tr>
<td>[PTV 60] V[54.0Gy] (%)</td>
<td>96.5944</td>
<td>IDEAL</td>
<td>Pass if &gt;95</td>
<td>IDEAL</td>
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<tr>
<td>[BODY] Max dose (Gy)</td>
<td>68.6118</td>
<td>IDEAL</td>
<td>Pass if &lt;69</td>
<td>IDEAL</td>
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<tr>
<td>[LT EYE] Max dose (Gy)</td>
<td>33.8118</td>
<td>IDEAL</td>
<td>Pass if &lt;60</td>
<td>IDEAL</td>
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<tr>
<td>[LT EYE] D[0.03cc] (Gy)</td>
<td>32.4716</td>
<td>IDEAL</td>
<td>Pass if &lt;54</td>
<td>IDEAL</td>
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<tr>
<td>[LT OPTIC NERVE] D[0.03cc] (Gy)</td>
<td>6.5616</td>
<td>IDEAL</td>
<td>Pass if &lt;45</td>
<td>IDEAL</td>
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<tr>
<td><strong>Total [5 Metrics]</strong></td>
<td><strong>5/0/0</strong></td>
<td><strong>5 Metrics</strong></td>
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Conventional 12Mev Electron plan

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12Mev Electron Bolus plan
12Mev Electron Bolus plan
Case Study

• How accurate and practical is the Bolus construction?

• You be the judge...

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Intact Breast Boost

• Intact Breast application of ECT

Reduce the dose to critical structures including the amount above the initial course prescription going to the whole breast volume.
Intact Breast Boost

### Quality Reports

#### Plan Quality Score Sheet: QUICK RT Breast (3-1 Metric(s) Renewed)

<table>
<thead>
<tr>
<th>Plan Quality Metric Component</th>
<th>Result</th>
<th>Score</th>
<th>Max Score</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>[PTV BOOST NEW] V(9.0Gy) (%)</td>
<td>99.8699</td>
<td>IDEAL</td>
<td>Pass if &gt;95</td>
<td>IDEAL</td>
</tr>
<tr>
<td>[HEART] Mean dose (Gy)</td>
<td>1.6553</td>
<td>OUT OF TOLERANCE</td>
<td>Pass if &lt;1.5</td>
<td>OUT OF TOLERANCE</td>
</tr>
<tr>
<td>[LUNG, L] D(20.0%) (Gy)</td>
<td>2.1949</td>
<td>IDEAL</td>
<td>Pass if &lt;5</td>
<td>IDEAL</td>
</tr>
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</table>

**Total [3 Metrics]**

2/0/1 3 Metrics

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#### Plan Quality Score Sheet: QUICK RT Breast (2 Metric(s) Renewed)

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<thead>
<tr>
<th>Plan Quality Metric Component</th>
<th>Result</th>
<th>Score</th>
<th>Max Score</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>[PTV BOOST NEW] V(9.0Gy) (%)</td>
<td>99.7397</td>
<td>IDEAL</td>
<td>Pass if &gt;95</td>
<td>IDEAL</td>
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<tr>
<td>[HEART] Mean dose (Gy)</td>
<td>0.5379</td>
<td>IDEAL</td>
<td>Pass if &lt;1.5</td>
<td>IDEAL</td>
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<tr>
<td>[LUNG, L] D(20.0%) (Gy)</td>
<td>0.6373</td>
<td>IDEAL</td>
<td>Pass if &lt;5</td>
<td>IDEAL</td>
</tr>
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**Total [3 Metrics]**

3/0/0 3 Metrics

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Intact Breast Boost

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Intact Breast Boost - Conformality

Conventional Electrons

Electron Conformal Therapy

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Questions????

• www.dotdecimal.com
Thanks to…. 

- .decimal®
- IU Health Goshen Center for Cancer Care
- Canis Lupus llc
- Varian Medical Systems
- Tomotherapy Inc.
- Dr James Wheeler, and Dr Houman Vaghefi