The SAVI® Applicator: Breast Brachytherapy Training
SAVI® Breast Brachytherapy

Greater flexibility
*Treats the widest array of cavity & breast sizes*

Enhanced performance
*Eliminates skin spacing restrictions*

Better outcomes
*Lowers toxicity & risk of persistent seroma*

Exceptional precision
*Sculpt dose with selective radiation*

Added convenience
*Simple, secure placement and removal*
SAVI Product Line

SAVI Applicator
• 6-1Mini
• 6-1
• 8-1
• 10-1

SAVI Prep Catheter
SAVI Applicator Details

- Catheter Protector
- Removable Expansion Tool
- Outer Catheter
- Center Catheter
- Handle
- Numbered Band
- Proximal Hub
- Radiopaque Marker
- Radiopaque Marker
- Distal Tip
Ideal SAVI Procedure Flow Chart

Pre-Implant CT Evaluation

SAVI Implanted

CT Simulation

Treatment Planning

Pre-Fraction QA and Treatment Delivery
SAVI Procedures

Pre-Implant CT Evaluation
Pre-Implant CT Evaluation (w/o SPC)

Performed ≤ 72 hours prior to implant

1. Obtain CT scan of breast to be treated
   - ≤ 3 mm slices
     - no gaps between slices
   - Patient arms up or down
   - Scan with breath hold if possible
   - Scan 2 cm superiorly and inferiorly beyond the cavity
   - Send CT data set to planning software

2. Have MD evaluate cavity and record data
   - Outline cavity margins on axial images
   - Determine volume (cc) of cavity
   - Measure the long axis (cm) and short axis (cm)
   - Assess the best insertion site and entry angle
4. Using that data, determine the most appropriate SAVI applicator size using the SAVI Size Reference Chart

5. Communicate SAVI size and cavity/insertion parameters to SAVI Representative and the Physician who will implant SAVI
SAVI Size Reference Chart

1. Size the Cavity - Measure the long axis and diameter of cavity under US.

2. Apply the SAVI Prep Catheter (SPC) - Fill SPC with saline based upon probable SAVI size until resistance is achieved.

3. Verify Conformance - Using ultrasound confirm conformance of SPC to cavity. If necessary increase fill volume until conformance is achieved.

4. Insert SAVI – compare measurement and select proper size.

<table>
<thead>
<tr>
<th>Diameter</th>
<th>2-3cm</th>
<th>3-4cm</th>
<th>4-5cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-3cm</td>
<td>SAVI Prep (20cc) 6-1Mini</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3-4cm</td>
<td>SAVI Prep (20cc) 6-1Mini</td>
<td>SAVI Prep (20cc) 6-1Mini</td>
<td>-</td>
</tr>
<tr>
<td>4-5cm</td>
<td>SAVI Prep (20cc) 6-1Mini</td>
<td>SAVI Prep (30cc) 6-1</td>
<td>SAVI Prep (30cc) 6-1</td>
</tr>
<tr>
<td>5-6cm</td>
<td>SAVI Prep (30cc) 6-1</td>
<td>SAVI Prep (30cc) 6-1</td>
<td>SAVI Prep (40cc) 8-1</td>
</tr>
<tr>
<td>6-7cm</td>
<td>SAVI Prep (30cc) 6-1</td>
<td>SAVI Prep (40cc) 8-1</td>
<td>SAVI Prep (40cc) 8-1</td>
</tr>
<tr>
<td>7-8cm</td>
<td>SAVI Prep (40cc) 8-1</td>
<td>SAVI Prep (60cc) 10-1</td>
<td>SAVI Prep (60cc) 10-1</td>
</tr>
</tbody>
</table>

*This chart is for reference only. Not intended to replace clinician discretion.
Pre-Implant CT Evaluation (w/SPC)

• The same procedure is followed as that w/o an SPC

• Since the surgeon is unlikely to create a new track once an SPC has been implanted, this procedure assists in determining the size of the SAVI to be implanted
Pre-Implant CT Evaluation (w/SPC)
CT Simulation
CT Simulation of SAVI Implant

CT Simulation is performed 24-48 hours post-implant

When patient arrives for the CT simulation:
1. Ask the patient for the expansion tool (surgeon should have given it to her).
2. Create an immobilization device. (e.g. Vac-Lock, alpha cradle)
3. Position patient on CT scanner and remove bandages.
   • Patient should be supine
   • Arms can be;
     • above head (typical),
     • akimbo or by her sides (if more comfortable)
CT Simulation of SAVI Implant

4. Place CT laser alignment marks on patient and immobilization device (for repositioning).

5. Remove the Catheter Protector from catheter #1
   - Insert expansion tool over catheter #1
   - Place in safe location to avoid damage and loss (e.g., emesis basin)
   - The expansion tool is used for each fraction, thus insertion for planning CT provides more exact reproduction of treatment setup.

Optional step:
   Insert a marker wire (or source position simulator) into catheter #1 (this will help identify the physical end of #1)

6. Acquire AP and lateral scouts (print or save)
Acquire planning CT data set:
- Use contiguous slices (e.g., no gaps)
  - 1.0 - 2.0 mm slice thickness
- Planning position must be used for treatment!
- Scan 2 cm superiorly and inferiorly beyond the cavity (or whole breast)

Evaluate implant in all three planes on CT console

If significant air pockets are present the device should be collapsed by the physician (left *in situ*), the air pockets massaged out and the device re-expanded and the CT repeated.

Remove expansion tool & marker wire from the SAVI (if used)

Replace the Catheter Protector in catheter #1
12. Measure and record* distance from \textit{skin surface to catheter handle} or use the scale on catheter 1 (depth assessment)

13. Mark white ring and skin in continuous line and fill in the "clock" diagram of the SAVI template provided (rotational assessment)

*Record measurement on SAVI Prescription and Treatment Summary Template
14. With the transfer guide tubes connected measure the catheter lengths and record. *(Patient does not need to be in treatment position)*

15. Retain the AP & lateral scouts as reference images for pre-fraction evaluation

16. Export CT to Treatment Planning Software
1. Place a wire on the lumpectomy scar prior to scanning.

2. Scanning with the key in place and marking the key and the #1 catheter to denote "seated" position as shown below:
CT Scouts
SAVI Procedures

Treatment Planning
Treatment Planning

– Structure Definition
– Applicator reconstruction
– Optimization and Prescription
– Evaluation
Case B

Slice 15

Slice 18

Slice 21

Slice 25

Slice 31
Create new body structures.

**Draw:**
- *External* = skin surface *(auto)* not illustrated
- *Lung* = lung surface *(magic wand)* not illustrated
- *Applicator* = SAVI, outside of struts *(perpendicular arbitrary plane, pearl)*
- *Cavity* = air or seroma inside or adjacent to applicator

**Generate:**
- *Chest Wall* = non-breast tissue *(margin from lung)*
- *PTV Opt* = 1.0 cm positive expansion of the *Applicator*, excluding *chest wall*, portion beyond *external*
- *PTV Eval* = *PTV Opt* minus *Cavity* *(Boolean operator)*.
- Non-conforming *(Cavity – Applicator)*
Define Structures
Define External
Define External
Draw Cavity

• Must use “Reconstructed Images”

• Using the “Point Selection” tool (right click), choose two points along the central lumen, one at the distal end and one at the proximal end

• These points do not have to be defined in the same plane or even the in the same view, i.e., one may be in the coronal view and the other may be in either the sagittal or the axial view
Draw Cavity

The first selected point is on an axial slice.

The second selected point is on a coronal slice.
Draw Cavity

• After the 2 points are selected, turn off the tool (right click, stop point selection)

• Toggle between images and the property palette

• Click the box marked “Perpendicular”

• This generates a plane orthogonal to the line created by the two points previously selected

• You should now be looking right down the central catheter
Draw Cavity

Stop Point selection
- Docking view
- View size
- Clear view
- Reset View
- Magnifying glass
- Measures
- Histogram equalization

3D Eye position drag-and-drop
- Magnification drag-and-drop
- Rotate
- Recon. slice drag-and-drop
- Slice selector
- Center and width
- Center and width rectangle
- Pan
- Zoom
- Zoom rectangle
- Drag-and-drop

Reconstructed slice
- Planes
  - Perpendicular
  - Orbit
  - Position: 58.0 mm
  - [Fine, Online]
  - Flip vertical
  - Flip horizontal

Orthogonal planes

CIANNA MEDICAL
Draw Cavity
Draw Cavity

• Now that we are looking right down the central shaft, the “Pearl” tool may be used to contour the cavity.

• Starting in the middle of the SAVI set the size of the Pearl to match the circumference of the applicator and click.

• Scroll up and continue until the end of the applicator is reached.

• This need not be done on every slice as Oncentra will interpolate the intermediate slices.
Draw Cavity

These are arbitrary plane slices on which the cavity was contoured
These are arbitrary plane slices on which the cavity was interpolated.
Draw Cavity

The resulting cavity contours should be reviewed on the original axial CT slices to ensure they were constructed correctly.
Define Structures

• Now is the time to define all other anatomic structures of interest, such as the Lung, Chestwall, Invag, etc.

• Any of the contouring tools may be used – the Magic Wand is excellent for lungs

• If there is a significant volume of air outside the applicator, you may want to contour that as well

• Typically all anatomic structures are contoured on the original axial slices, but they may be contoured on any slice in any plane
Generate *PTV-Opt*

- Make sure the ROI “*Cavity*” is selected

- Under the ROI menu, select “ROI Margin”

- This allows you to expand the cavity 10 mm in all directions but limits its extent by the amount that is entered in the thickness column next to the anatomic structure previously defined

- For example, if 2 is entered next to *External*, the expanded cavity will not go closer to the skin than 2 mm
Generate PTV-Opt
Generate *PTV-Opt*

- Click on “Calculate”
- Click “Make new ROI”
- Choose the name for this ROI
- Verify the expansion has occupied the intended volume, simplify and save
Generate PTV-Eval

- To generate the PTV-Eval from the PTV-Opt, make sure that PTV-Opt is the selected ROI
- Click on the “Subtraction” tool under ROI
- Select the ROI you wish to subtract from the PTV-Opt (in this case, the Cavity) and click on “Apply”
- Add back any invaginated tissue (Invag)
- Generate this as a new ROI and call it PTV-Eval
- To make a B-39 compliant PTV-Eval, subtract pectoralis as well as a 5 mm margin inside External
Generate \textit{PTV-Eval}

- Scroll through the original axial slices to ensure that the \textit{PTV-Eval} has been constructed appropriately

- Use colorwash just on the \textit{PTV-Eval} for ease in viewing

- When satisfied with this contour, simplify but uncheck “Remove holes” and “Keep single polygon only”

- \textbf{SAVE, SAVE, SAVE}
Generate $PTV$-Eval
Generate PTV-Eval
Generate *Non-conforming*

If there are nonconforming regions around the SAVI device (either air or seroma), it should be contoured as a separate ROI.

The volume of nonconformance within the $PTV_{Eval}$ should be no greater than 10% of the entire $PTV_{Eval}$.

Viable option: Using the Boolean operator “Union” under the ROI dropdown, union the air with the cavity prior to expanding the cavity into the $PTV_{Opt}$. This will effectively add the non-conforming air to the cavity so the $PTV_{Eval}$ and $PTV_{Opt}$ will expand 10 mm beyond the non-conforming air.
Similarly, if there is breast tissue between and/or within the struts creeping into the cavity (invaginations), these invaginations should be contoured as a separate ROI.

Viable option: Using the Boolean operator “Subtraction” under the ROI dropdown, subtract the invaginating tissue from the cavity prior to expanding the cavity into the $PTV_{Opt}$. This will effectively subtract the invaginating tissue from the cavity so when the $PTV_{Eval}$ and $PTV_{Opt}$ are expanded 10 mm beyond the cavity, this invaginating breast tissue which must be treated will be included in the treatment volume.
Generate Non-conforming
Structure Volumes

Volume stats:
- SAVI = 63.2 cc
- PTV_Opt = 155.4 cc (Rx surface)
- PTV_Eval = 92.2 cc
- Nonconforming Air = 10.2 cc
- New cavity including air = 70.8 cc
- New PTV_Eval = 119.9 cc
Applicator Reconstruction
Anatomy of SAVI

- Catheter #6 Proximal Marker
- First dwell position for outer catheters
- Catheter #2 Distal Marker
- First dwell position for center catheter
- Catheter #4 Medial Marker
Anatomy of SAVI

SAVI DISTAL END

- Peripheral Catheter
- Center Catheter
- Metal Strut
- Metal Locking Ring

Dimensions:
- 3 mm
- 2.9 mm
- 8.4 mm
- 11.3 mm
Applicator Reconstruction
Applicator Reconstruction
Applicator Reconstruction

- Strut 2
- Distal end
- Strut 4
- Equator of SAVI
- Strut 6
- Proximal end
Applicator Reconstruction
Applicator Reconstruction

Tomographic Data

Preferences
- Sequencing: No Sequencing

Catheters
- Number of catheters: 1
- Add (+1)
- Remove (-1)
- Remove All

Current Catheter
- Index: 1
- Prev
- Next
- Offset: 0 mm
- In Sequence
- Flip Current Catheter
- Delete Current Catheter

Applicator properties
- Source Step: 5.0 mm
- Start At: Tip End

Visualization
- Project catheters

First Point

Second Point
Applicator Reconstruction

Rotate the x-axis such that it goes through Point 1 and Point 2

Strut 2 appears in the x-y plane

This is confirmed by the marker on the distal end as well as the point P2 on the strut

Begin to reconstruct Strut 2 within 2 mm of the end of the metal band at the distal end of the applicator

Follow ABOVE the white strut marker as this is where the source will travel (ignoring the marker)
Repeat this process for all the struts in the applicator

SAVE AFTER EACH STRUT IS RECONSTRUCTED!!

Verify all is correct on the 3-D view
Struts 4 and 6 can be verified by the metal bands as well as the point numbers.

This is strut 4 as an example.
Applicator Reconstruction

The 3-D reconstructed SAVI 10-1 applicator
Target Points
Target Points

1. Go to the points menu and choose Target Points
2. Select PTV-Opt from the pull down menu.
3. Change the default number of points to greater than 200 points if necessary and hit <Enter>
4. Normalize to Target Points
5. Fill in Prescription
6. Optimize using Points → Volume
7. If adjustments are necessary use Graphical Optimization → Local and begin manually adjusting isodose lines.

![Optimization menu screenshot]
IPSA Optimization
Set the PTV_OPT surface dose objective to range between 340 cGy and 380 cGy.

The minimum surface dose will be the prescription dose.

Maximum dose for the volume is set at 150% of Rx.

Objective weights can vary on a case by case basis.
Scroll through the original axial images and evaluate the dose distribution

Use Graphical Optimization to pull the isodose curves to a more desirable location
Note the conformality of the prescription isodose line with the *PTV_Eval*

Also note how this line stays off the skin and the chest wall
IPSA Optimization

<table>
<thead>
<tr>
<th>ROI</th>
<th>Dose [%]</th>
<th>Dose [cGy]</th>
<th>Volume [%]</th>
<th>Volume [ccm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTV_EVAL</td>
<td>95.00</td>
<td>323.00</td>
<td>95.54</td>
<td>98.94</td>
</tr>
<tr>
<td>PTV_EVAL</td>
<td>100.00</td>
<td>340.00</td>
<td>91.08</td>
<td>94.32</td>
</tr>
<tr>
<td>PTV_EVAL</td>
<td>150.00</td>
<td>510.00</td>
<td>36.58</td>
<td>37.88</td>
</tr>
<tr>
<td>PTV_EVAL</td>
<td>200.00</td>
<td>680.00</td>
<td>14.70</td>
<td>15.23</td>
</tr>
</tbody>
</table>
IPSA Optimization

<table>
<thead>
<tr>
<th>RCI</th>
<th>Dose [%]</th>
<th>Dose [cGy]</th>
<th>Volume [%]</th>
<th>Volume [ccm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTV_EVAL</td>
<td>95.00</td>
<td>323.00</td>
<td>98.21</td>
<td>101.70</td>
</tr>
<tr>
<td>PTV_EVAL</td>
<td>100.00</td>
<td>340.00</td>
<td>95.56</td>
<td>98.96</td>
</tr>
<tr>
<td>PTV_EVAL</td>
<td>150.00</td>
<td>510.00</td>
<td>42.74</td>
<td>44.25</td>
</tr>
<tr>
<td>PTV_EVAL</td>
<td>200.00</td>
<td>680.00</td>
<td>17.99</td>
<td>18.52</td>
</tr>
</tbody>
</table>
## Plan Evaluation

<table>
<thead>
<tr>
<th></th>
<th>Interstitial (RTOG B-39)</th>
<th>MammoSite (RTOG B-39)</th>
<th>SAVI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>V90</strong></td>
<td>&gt; 90%</td>
<td>&gt; 90%</td>
<td>&gt; 90%</td>
</tr>
<tr>
<td><strong>V150</strong></td>
<td>≤ 70 cc</td>
<td>≤ 50 cc</td>
<td>≤ 50 cc</td>
</tr>
<tr>
<td><strong>V200</strong></td>
<td>≤ 20 cc</td>
<td>≤ 10 cc</td>
<td>≤ 20 cc</td>
</tr>
</tbody>
</table>
SAVI Procedure

Pre-Fraction QA and Treatment Delivery
Pre-Fraction QA

1. Remove all dressings
2. Position patient on CT table to match original positioning
3. Align marks on patient with CT simulator lasers
4. Measure distance from skin to central channel handle
   a. Compare to reference value taken at planning CT
5. Check for rotation
6. Record data on “SAVI Prescription and Treatment Summary Template”

6-1 and 6-1 Mini

8-1

10-1
7. Acquire AP and lateral scouts and axial images

8. Evaluate scouts for movement or rotation of SAVI by measuring the 2, 4 and 6 markers with respect to patient anatomy.

9. If changes are noted notify Physician to re-plan/reposition device if needed
Scouts: Baseline & Fraction 1 AP Scouts
Scouts: Baseline & Fraction 1 Laterals

Patient setup assessment
Black: gap between tip and sternum is ~10 mm

Device assessment
Red: #2 is almost on center (same)
Blue: #4 at outer edge of device (same)
Yellow: 2 struts @ center have ~ 3mm gap
Green: #6 is slightly inside an outer strut

Patient setup assessment
Black: gap between tip and sternum is ~6-7 mm (close setup)

Device assessment
Red: #2 is almost on center (same)
Blue: #4 at outer edge of device (same)
Yellow: 2 struts @ center have ~ 3mm gap
Green: #6 is slightly inside an outer strut (almost same)
Scouts: Baseline & Fraction 1 AP Scouts

**Impression:**
- Patient setup shows slight rotation, right-side slightly towards posterior.
- SAVI appears almost perfectly reproduced in AP & laterals.
- Slight changes in SAVI markers consistent with slight changes in patient rotation, not SAVI rotation.

**Patient setup assessment**
- **Red:** distal tip at lateral edge of ribs
- **Green:** #2 is at center of ribs

**Device assessment**
- **Blue:** #4 slightly inside the outer edge of device
- **Yellow:** #6 strut @ outer edge and ~1mm from “touching” center
- **Green:** #2 is at outer edge of device
1. In the HDR suite, position patient as for the CT Simulation

2. Remove the Catheter Protectors and store in safe location

3. Insert the Expansion Tool over the center catheter until properly engaged into the fitting of the SAVI™ applicator (NOTE: important for potential emergency response)

3. Obtain requisite number of transfer tubes
   – SAVI 6-1 requires seven transfer tubes (#1-7)
   – SAVI 8-1 requires nine transfer tubes (#1-9)
   – SAVI 10-1 requires eleven transfer tubes (#1-11)

4. Insert proximal end of SAVI catheter #1 into the catheter connector on the distal end of transfer tube #1

5. Insert the proximal end of transfer tube #1 into the HDR unit turret’s #1 opening.
6. Repeat step 5 until all transfer guide tubes are connected
7. Double-check the connection numbers of the SAVI applicator, transfer guide tubes and at the turret.
8. Reposition HDR unit to maintain straightness of transfer guide tubes (as much as possible).
9. Verify each transfer guide tube connection is connected properly, and that indexer is locked.
10. Follow SOPs for fraction delivery

11. Disconnect patient from HDR unit, disconnect transfer guide tubes from SAVI

12. Insert purple Catheter Protectors.

13. Re-bandage or dress the SAVI-skin entrance site using standard techniques
Interesting Case

Inverted Strut
Inverted Strut
Inverted Strut
Inverted Strut - Planned
Clinical Views
Clinical Views
Advantages Over Other Techniques

• Ability to have dose modulation at skin surface and chest-wall/lung interface
• Minimal constraints on cavity conformity
• Flexibility in size used, and expansion needed for versatility
Thank you!