Intensity Modulated Radiation Therapy for the Treatment of Breast Cancer

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Whole Breast Radiotherapy

- Whole breast RT following lumpectomy has an important role in the treatment of early stage breast cancer
- Potential side effects:
  - Acute: painful erythema & desquamation
  - Chronic: hyper-pigmentation, fibrosis, fat necrosis, pain
- The incidence and severity of side effects is managed by minimizing "hot spots"

Goals of IMRT for Breast Cancer

- Optimize dose homogeneity, avoid unnecessary normal tissue irradiation and standardize target volume
- Determine if simple IMRT can be used practically and reproducibly in the clinic
- Precursor to more advanced IMRT applications:
  - Breast + IM-node irradiation
  - Quadrant irradiation

IMRT Process

- Simulation
- Treatment Planning
- Treatment Delivery
- Quality Assurance

Initial Simulation

- Immobilization: alpha-cradle
- Position arms above head, keeping elbows tucked in
- Treatment side of the cradle is compressed to avoid interference with the lateral tangent setup and SSD readings

Initial Simulation

- Position the patient level and straighten under fluoroscopy
- Level marks (tattoos) are made on each side of the patient at about 5 cm below xiphoid with the lateral lasers
- Tattoos at ~10 cm off the tabletop

CT Scan

- Position patient level and straighten on the table using the midline, level marks, and the marks on the cradle
- Place a "b.b." on midline, if the medial wire placed by physician is not located on the midline

CT Scan

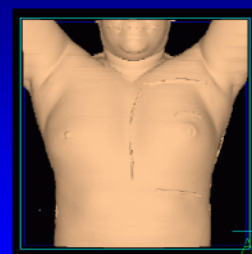
- Patient should be in the center of the table, unless the affected breast is too large
- If the treatment site is not in the field of view, move the patient off-center to assure a complete scan of the affected breast

CT Scan

- Acquire a scout view of the entire chest, start superiorly from the chin and end inferiorly below the leveling marks.
- Image set should include above and below the 1st and 12th thoracic rib respectively.
- Set center of the field (zero slice) in middle of the breast, between catheters placed by physician.
- Scan the central axis slice; check for straightness and rotation.

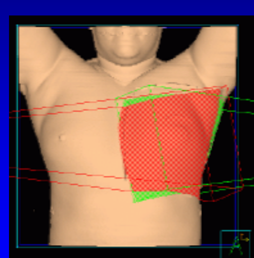
Virtual Simulation

- Virtual CT simulation in the standard treatment position
- Treating physician places radio-opaque markers at the clinical borders of the ipsilateral breast tissue



Virtual Simulation

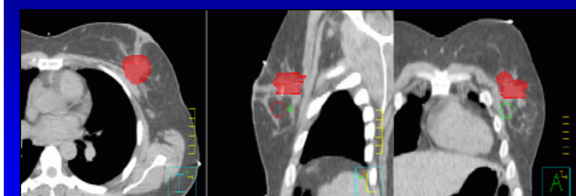
- During treatment planning: the superior, inferior, and deep edges of the unopposed tangential beams are aligned with the radio-opaque markers



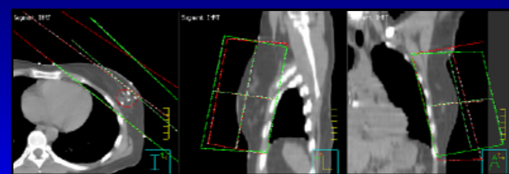
Treatment Planning

- Contour
- Beam alignment
- Beam weight
- IMRT plan

Delineate Lumpectomy Cavity

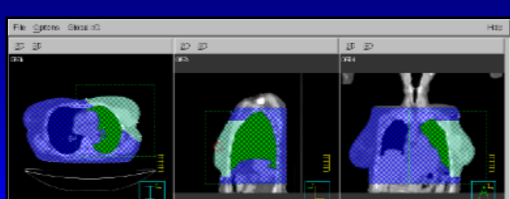


Tangent Beam Alignment



- Align tangential beams to coincide with radio-opaque markers
- 2 cm anterior fall off
- 1.5 cm - 2 cm depth into lung

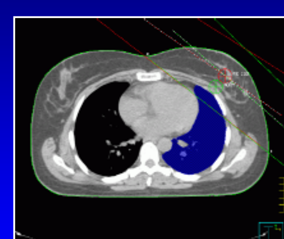
SKIN, LUNG, and BREAST



- Contour skin and lung
- Create breast contour through contraction tool

CONTOURS - Skin & Lung

- Auto contour skin and lung
- Lung
  - lower threshold 150
  - upper threshold 800



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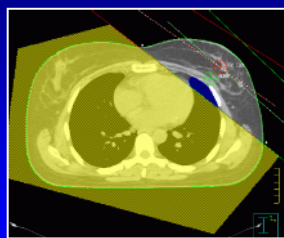
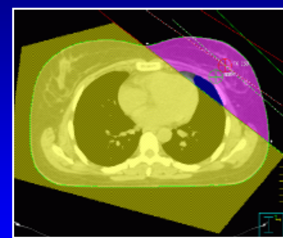
CONTOURS - Beam Edge

- Contour the tangential beam edge to create a “Dummy ROI”



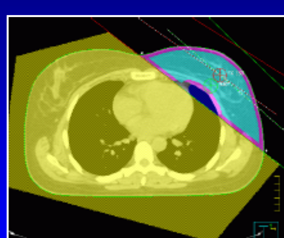
CONTOURS - Breast

- Create breast contour through contraction tool
  - Skin source ROI
  - Lung and dummy limiting ROI
- Edit breast contour along heart



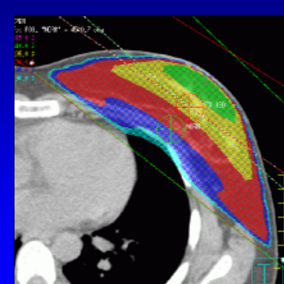
CONTOURS - PTV_eval

- Create PTV_EVAL by contracting BREAST ROI by 5mm

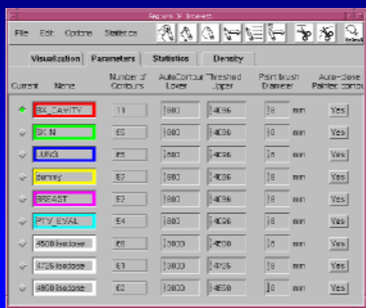


Beam Weight

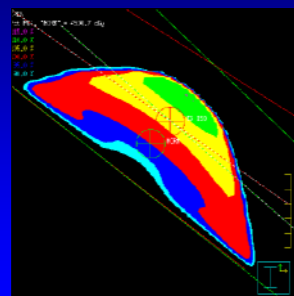
- Open field plan is created
- Heterogenity correction is utilized
- Beams are weighted to a normalization point 1 cm anterior to the chestwall



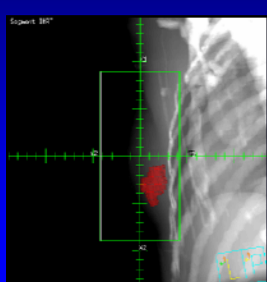
Regions of Interest



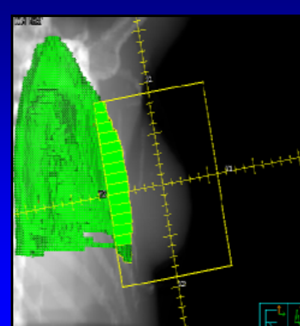
Dose Segment - ROI



Beam Segments - Open Field

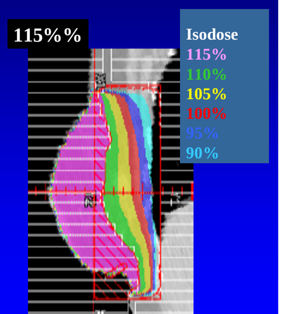


BEV: Block to Lung

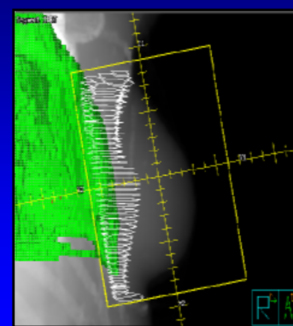


MLC Segments

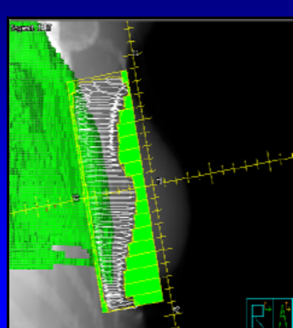
- Calculate an isodose distribution for a pair of open tangential fields (no blocks or wedges)
- Subdivide medial and lateral beams into MLC segments; conform to isodose lines, in 5% increments, i.e., 120%,115%,110%, 105% …



BEV: Dose ROI

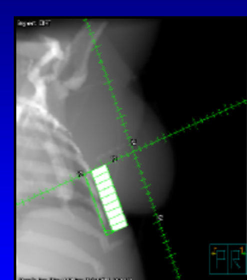


BEV: Block to Dose ROI



MLC Segments

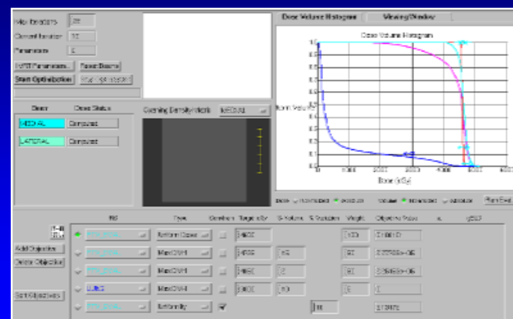
- Open Field
- Lung Block
- Multiple Segments



IMRT: Optimization

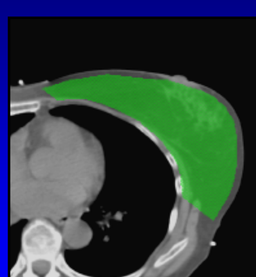
- Minimum dose of 45 Gy in 1.8 Gy fractions
- IMRT is used to achieve dose uniformity:
  - Less than 15% of breast volume should receive > 105%
  - Less than 2% of breast volume should receive > 110%
  - Maximum 10% of one lung can exceed 30 Gy

IMRT: Optimization



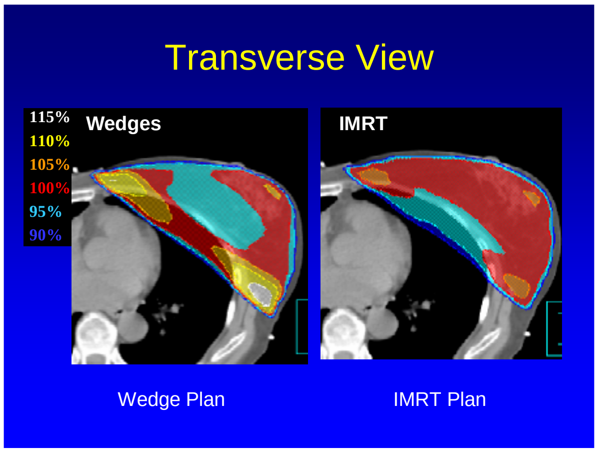
MLC Segment Optimization

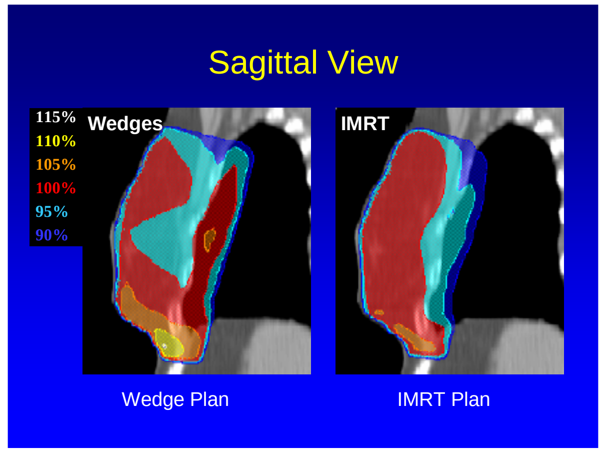
- Beam weights optimized to deliver an equal dose to a volume (1.8Gy X 25 = 45Gy)
- Typically, > 80% of dose is delivered with the open fields
- If segments deliver less than 2 monitor units, delete and re-optimize weights
- Whole breast IMRT usually requires 6 to 8 total beam segments

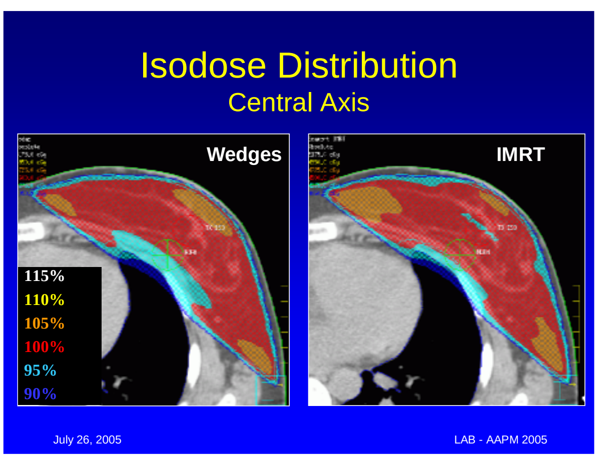


Pan Evaluation

- Dose uniformity is achieved throughout the treatment volume
- <15% of breast volume receives >105% of the prescribed dose
- < 2% of breast volume receives >110% of the prescribed dose


Transverse View
115%
110%
105%
100%
95%
90%
Wedges
IMRT
Wedge Plan
IMRT Plan


Sagittal View
115%
110%
105%
100%
95%
90%
Wedges
IMRT
Wedge Plan
IMRT Plan


Isodose Distribution
Central Axis
Wedges
IMRT
115%
110%
105%
100%
95%
90%
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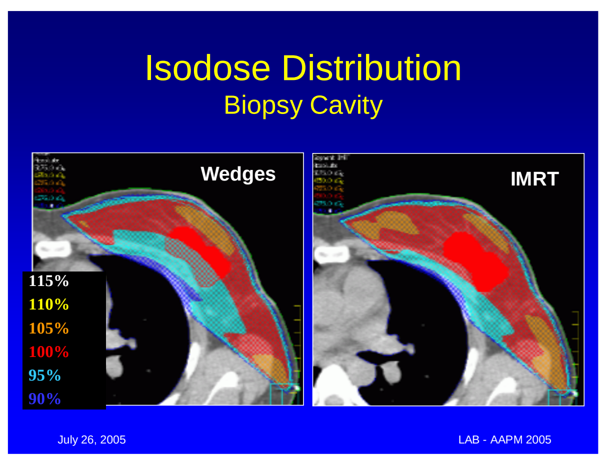
Isodose Distribution
Biopsy Cavity
Wedges
IMRT
115%
110%
105%
100%
95%
90%
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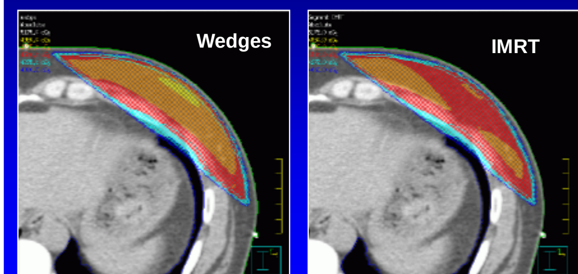
Isodose Distribution

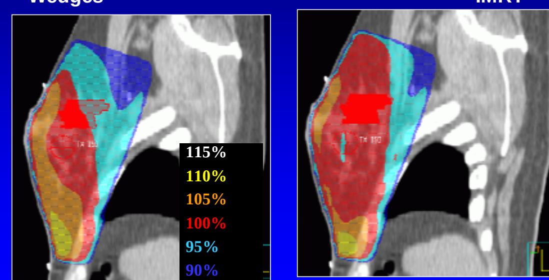
Inframammary Fold



Isodose Distribution

Sagittal View

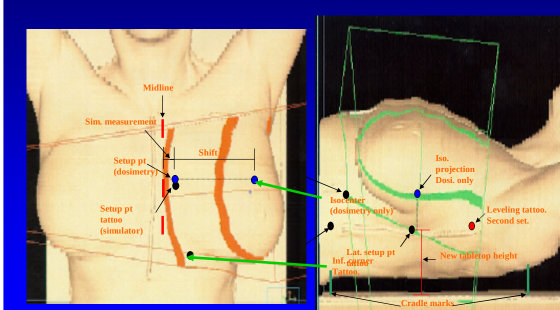
Wedges IMRT



Treatment Delivery

- Treatment time (~10 minutes) is not increased compared to conventional techniques
- Electronic portal images of medial and lateral daily
- Image acquired during first few monitor units of open segment

Treatment Delivery



Quality Assurance

- Hand calculation at isocenter
- Central axis diode measurement
- Daily electronic portal verification
- Segment review
- MapCheck measurements

MU hand calculation

<u>Simple IMRT cases:</u>

- MU hand calculation still possible
  Modulation factor (MF)
  F is the fractional MU weights for MLC segments contributing to the calculation point

$$MF = \sum_{i=0}^{all\_open} F_i$$

Quality Assurance

- IVD Dosimeter
  – Sun Nuclear Corporation
- Calculate given dose
  – measurements made first day of treatment
  – compared to calculated value

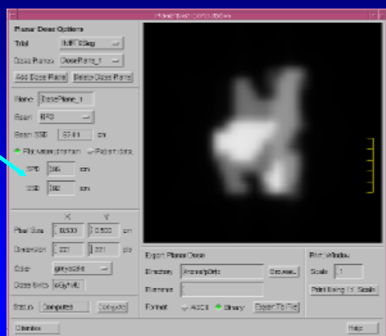
Routine IMRT QA at WBH

Individual beam approach:

- Absolute dose measurements
  – **MapCheck from Sun Nuclear**
  – Tolerance:3%

- 2D dosimetry
  - MapCheck from Sun Nuclear
  - Pinnacle planar dose tool (1mm resolution)
  - Tolerances used with MapCheck: 3% and 2 mm of distance to agreement

SPD and SSD must be specified carefully for Mapcheck.



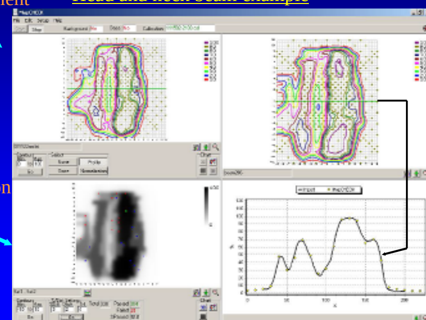
MapCheck software

MapCheck measurement

Head and neck beam example

Pinnacle dose map

Comparison window



Summary: Whole Breast IMRT

- Whole breast IMRT achieves more uniform dose distribution compared to conventional methods
- IMRT treatment planning adds 30 minutes to CT/virtual simulation (~2hrs total planning time)
- Treatment time (~10 minutes) is not increased compared to conventional techniques
- Dosimetric and organ motion studies confirmed that the necessary dose conformity can be achieved clinically with current IMRT technologies

References

- Kestin LL, Sharpe MB, et al. Intensity modulation to improve dose uniformity with tangential breast radiotherapy: initial clinical experience. IJROBP, 2000;48: 1559-1568.
- Vincini FA, Sharpe MB, et al. Optimizing Breast Cancer Treatment Efficacy with Intensity-Modulated Radiotherapy. IJROBP, 2002;54:1336 –1344.
- Remouchamps VM, Letts N, et al.Three-dimensional evaluation of intra- and interfraction immobilization of lung and chest wall using active breathing control: a reproducibility study with breast cancer patients. IJROBP, 2003; 57: 968 – 978

Thank You

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