Objectives:

- To understand important variables in applicator design and use.
  - emphasis on Tandem and Ring applicators
  - Tandem and Ovoids, Tandem and Cylinder, similar treatment goals
  - cylinders

- To understand the treatment planning process for CT and MRI

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Geometry: Cylinder Geometry

- Simple geometry, effectively a straight line
- Cylinder diameters
  - 2.0cm, 2.5cm, 3.0cm, 3.5cm and 4.0cm (CT/MR also)
- Cylinder lengths
  - domed segment
  - 2.5cm segments
Orthogonal Films: Cylinder

- Fixed geometry - applicator is fixed together
- Choose combination of diameter and physical length according to anatomy
- Dosimetry needed only for 1st fraction
- Adapt fraction to fraction if needed
Vaginal Cylinders in CT Planning-
traditional and compatible

- 2 cm and 4 cm diameter standard cylinders above
- 3.5 cm diameter CT/MR compatible cylinders to left
- Surprisingly minimal artifacts on axial CT slices for the larger diameter cylinders
Cylinder: Summary

Anything you can do with traditional films in treatment planning...

You can do with CT based planning.
Geometry: CT/MR Compatible Tandem & Ring

- Same basic geometry
  - FIXED geometry
  - ‘snaps’ in place
- Slightly larger tandem diameter
- Somewhat more fragile
  - have broken one so far
- Minimal artifacts
  - easier to see tissue
  - harder to reconstruct
- **Fixed geometry** - tandem fixed in center of ring
  - x-ray marker strands help visualize
  - reconstruction can show errors in placement or connections
  - reconstructed geometry is often a double check of the implant geometry
Tandem & Ring Planning-final views

- The applicator orthogonal axes (CT or MR)
  - user defined-i.e. ADJUST them
  - follows the natural planes of the applicator
  - x-ray marker strands help identify catheters
- Easier for planning and display, but sometimes harder to contour
  - native vs. reconstructed image quality
  - contour on native CT axes views
  - compare/review in reconstructed views
  - compare both structures AND applicators
Tandem & Ring Planning

Dosimetry needed only for 1st fraction?

- there can be extreme changes in normal anatomy from fraction to fraction
- Adapt fraction to fraction as needed
- if you have to treat with a prior plan then…
- follow up with post treatment dosimetry
Various Points of Interest

**Applicator Points**

- relative to ‘Applicator Axes’
- keyboard entry
- Para-Coronal view
- Reference from Smit sleeve or cervical marker ball or applicator surface or …
- Point A is defined at a POINT, 2cm up from ring surface and 2cm lateral to tandem
- Point B - 2cm superior from ring surface and 5cm lateral to midline
- Point T - 1cm superior to ring surface and 1cm lateral to tandem
Various Points of Interest

- **Patient Points**
  (digitized from films or CT images)
  - points of interest where we monitor dose identified by physician or physicist
  - contoured normal tissues
  - contrast based placement
    - choose expected hot spots based on contrast enhanced anatomy
  - points OR volumes…
Dose optimization points are tapered along the tandem axis
- 12mm, 14mm, 16mm, 18mm, 20mm down to level of Point A
Dwell locations down to ring, but not caudal into the vagina
Creates an approximate ‘pear’ shape
Dose optimization points can also be used to modify the classic location of dose specification (Point A)
- 1.8 cm, 1.5 cm, 1.2 cm lateral prescription distances
Even with film based planning, you can use CT scan information to get uterine wall thickness and adjust dose optimization AND prescription points
Activate dwell positions of 360° circle in accordance with disease location and ring diameter (not entire ring)

- symmetric sparing of anterior and posterior vaginal surface, close to the bladder and rectum, similar to Tandem and Ovoid treatments
- optimize/prescribe to the surface of the ring 6 mm radial from dwell positions with a percentage of the prescription dose
- possible to have a slight posterior dose enhancement
- we never load the full ring for treatment
- ***Tandem and Cylinder treatments DO treat the entire radial surface within the active treatment length of the vagina, so be more cautious
Too Many Points?

- **Dose Optimization Points**
  - control the shape of the isodose distribution
  - determine relative dwell weights by assigning relative weights to the dose optimization points
  - e.g. 100% to the tandem taper and 140% to vaginal surface

- **Prescription Points**
  - define the absolute value of the isodose lines
  - scale the entire dose distribution, turning relative dwell weights into absolute dwell times for treatment delivery
  - prescription can be defined in several ways
  - true DVH planning/evaluation...
    - multicatheter breasts, we prescribe a percent of the Rx to a percentage of the PTV
    - NOT yet to the ‘automated’ planning stage of using a goal or wish list set of treatment parameters similar to IMRT
    - See ABS/GEC-ESTRO brachytherapy recommendations
MRI Planning

- IF you use only the MR images for planning
  - Improved tumor/target recognition
  - No commercial MRI markers to visualize possible dwell positions?
- Even harder to visualize applicators
  - Compared to CT scans
  - Hard to identify possible dwell positions
MRI Fusion

- Fuse to orthogonal film information
  - iterative planning
- Fuse to CT scan information
  - our department’s focus
    - identify tip of tandem
    - identify handles of applicator
  - contour on MRI for targets
  - fuse MRI to CT
  - reconstruct applicators on CT
  - add contours for normal tissues on CT (rectum, bladder and sigmoid)
  - plan on CT images
  - minimal scan set up differences needed
MRI Fusion-continued

- **Fuse to other MRI scans**
  - different weightings to highlight different aspects of the image
  - possibly enhance applicator and markers
  - identity matched for easiest fusion

- **Difficulties**
  - multistep fusion is not possible(?), all fusion must be to one base image set, usually the CT image
  - image quality of reconstructed views is not as good as native views (e.g. coronal and sagittal), depends on slice thickness
  - still uncertain about dwell position locations in MRI scans
Our prescription is implied for the volume not just Point A

- We hope to move to consistent DVH prescription protocol based on MRI targets but there are still uncertainties

Must be clear and consistent in your planning process and reporting

- redundant information is a necessity when adapting to different planning methods

Team approach, be prepared to communicate, inform and assist as necessary