Going Clinical with the Accuray Radixact™ System

The Montefiore Experience
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Financial Disclosure

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Montefiore Medical System

- Founded in 1888
- Over 20 primary and specialty centers serving the Bronx and Westchester regions of New York.
- Strong history of acquiring new technology for radiation oncology.

Radiation therapy with the world’s first clinical 35 MV Betatron (1962)

Photograph courtesy of George Zacharopolous
Current Clinical Environment

• Staff has strong experience with Varian technology
  – Aria® Oncology Information System
  – Eclipse™ External Beam Treatment Planning
  – TrueBeam® STx, Trilogy®, 2 Clinac® 2100C

• Paperless medical records
  – All patient documentation and records kept to Aria™
  – Integrated with Epic electronic health record system
The Challenge

• Integrating the Radixact™ System into a Varian environment
  – Minimize the impact of introducing new technology
  – Seamless integration with clinical workflow

• Establish who will be leading the effort out of each clinical group
  – Therapist, Dosimetrist, Physicists
  – Train them early and have them intimately involved with incorporating the new technology before involving the rest of the staff

• Physicists are ultimately responsible for the success of integrating new technology in a Rad Onc clinic
Transition to Clinical Use

• Commissioning phase:
  – Used a RANDO phantom to validate the entire workflow from CT simulation to treatment delivery.
  – Developed the warm-up procedure for therapist to follow
    • PowerPoint presentation showing *every step in detail* including screen shots
  – Staff trained in emergency procedures

• Clinical initiation:
  – Slow ramp up of clinical load
    • 4 patients added per week
    • Allowed therapists to achieve comfort level
Aria® OIS Treatment Workflow

• Utilized Accuray OIS Connect™ Option and Varian DICOM Worklist Interface to integrate Radixact™ System with Varian OIS

• Treatment workflow:
  – Patient is scheduled in Aria® Time Planner for treatment
  – Patient is checked-in in Aria® Time Planner
  – Patient now appears in list at Radixact™ System treatment console
  – Patient is imaged and treated
  – Popup window appears on Aria™ workstation for charge capture.
  – Automatic transfer of fraction dose and MVCT/kVCT registration to Aria™
  – Physicians can review daily image registration in Aria™ Off-Line Review
Aria® OIS Treatment Workflow

- Therapist verify dose accumulation and image registration to Varian OIS with Varian RT Summary
Interrupted Treatments

- Dose recording and CTrue™ Daily Image registrations can be sent manually from Accuray Precision™ Treatment Planning System in the case of a treatment interruption that is subsequently completed.
OIS Connectivity

• Therapists checks for VMS (Varian Medical System) services running on Windows workstation during morning warmup.

• Physicists can ping connection from Accuray iDMS™ Data Management System to Varian OIS servers.
Daily Setup and Imaging

- Therapist images the entire PTV with MVCT
  - Yaw and Pitch corrections not applied but calculated for image registration to confirm patient setup
    - Pitch is critical for extended PTVs (GYN with para-aortic)
    - Yaw important for H&N setups
  - Translations and Roll corrections used to shift patient and starting gantry position
Treatment Planning Workflow

• Physicians contour target and critical structures in Eclipse™
• Attending physician approves structure set in Eclipse™

• Dosimetrist transfers CT image and structure set to Accuray Precision™ Treatment Planning System and generates plan
• Attending physician reviews plan in Accuray Precision™ System and approves for treatment
  – RTPlan, RTTS, and CT with couch replaced DICOM files transfers to Aria® automatically upon approval

• Physicist reviews plan in Accuray Precision™ Treatment Planning System and approves treatment plan for delivery in Aria®
Rescan Plans

• Typically we rescan kVCT images for prostate patients on 23rd fraction and H&N patients on 15th fraction and recalculate dose onto new CT image.

• Rescan kVCT uploaded to Accuray Precision™ Treatment Planning System and used in the Retreatment module

• Deformed dose distribution exported to Eclipse™ and associated with a plan

• Physicians review the dose distribution to determine if a new plan is appropriate.
Treatment Planning

• Four concepts new to experienced Eclipse™ treatment planners:
  
  – Pitch
  
  – Target and critical structure overlap priority
  
  – Critical structure beam intersection
  
  – Modulation Factor and Leaf-open time (LOT)
Pitch

• Pitch is a complex concept but easy to deal with.

• Use published table for pitch selection
  – Dependent on field width, dose/fraction, and off-axis extent of PTV
  – Theoretical analysis of the thread effect in helical TomoTherapy, Chen et al., Medical Physics 38 5948 (2011)

• Pitch is discussed in-depth during training and published tables are provided by Accuray

• Use the highest pitch possible to reduce fast leaf open times
  – Less stress on MLCs
  – Better measured QA results
Overlap Priority

- Every pixel is associated with one target and one critical structure (if one or more ROIs overlay the pixel)
  - Prescription PTV must have highest priority (left image)
  - The right image shows the effect of CTVs having higher priority than PTV for optimization (introduction of cavity)
  - Be careful of tuning structures inside prescription PTV
Overlap Priority

• Structures imported from Eclipse™ initially have priorities associated to location on structure list.
  – Planner should prioritize contours before planning
  – Physicist should check structure priority when reviewing plan

• Automatic generated skin contour is first on list of Eclipse™ structure set and therefore comes in as highest priority critical structure.
  – Will render all optimizations on critical structures void unless the overlap priority is set to last.
Beam Intersection

- Each critical structure has three possible relationships beam intersection:
  - Never: No beamlets pass through the structure
  - Allowed: Beamlets can pass through the structure
  - Exit Only: Beamlets can pass through the structure but only after passing through a target first
Beam Intersection

• Excellent tool for sparing critical structures
  – Improved rectal sparing in prostate plans
  – Improved residual parotid sparing in H&N plans
  – Critical structures in brain

• Can block shoulders and positioning device in H&N treatments
  – RapidArc™ cannot do this so we still rely on 9-field fixed beam IMRT on Varian linacs
  – Result is H&N treatments are more efficiently delivered on Radixact™ System
AAPM TG-119

• IMRT commissioning: multi-institutional planning and dosimetry comparison

• TG-119 is a useful tool for dosimetrists and physicists to understand the optimization engine.

• Contour sets downloadable from AAPM website
  – Mock prostate, mock Head & Neck, C-shape

• Results can be compared to institutions in TG-119 report
The C-Shape plan offers an excellent means to review impact of beam intersection on critical core structure.

“Exit-only” beam intersection

“Never” beam intersection
Modulation Factor

- The Modulation Factor (MF) is a parameter that allows planners to control highly modulated IMRT plans for complex target volumes and critical structure geometries.
  - Result is longer maximum leaf open times (LOT)
  - \( MF = \frac{LOT_{\text{max}}}{LOT_{\text{mean}}} \)

- High MF values result in longer treatment times with marginal improvement to plan quality
  - Total treatment time = \( LOT_{\text{max}} \times 51 \times \) active rotations

- Planners usually start with a high MF to achieve ideal IMRT plan then reduce MF until plan quality starts to degrade
  - Can be inefficient to search for ideal MF
Leaf-Open Time (LOT)

- LOT distribution plot is an excellent tool for creating more efficient treatment deliveries
H&N planning

- 69.96 Gy SIB plan: 11 minutes, 40 seconds
- Visual inspection of LOT distribution led to a cutoff value of 300 msec.
  - New plan $MF = \frac{400}{168} = 2.4$ (continued optimization for 100 iterations)
- New plan is 6 min, 45 secs
H&N planning

• Difference in plan quality is negligible
Spine SBRT

- Plan dose: 12 Gy, 1 fraction
  - Initial plan was 30 minutes long!
  - Treatment reduced to 15 minutes by reducing plan MF and changing pitch
  - Actual MF did not significantly change because the mean LOT shifted also
Spine SBRT

- Plan quality is comparable
  - Slightly more dose to critical structures but clinically acceptable
Physics – Clinical Preparations

• The Radixact™ System comes practically pre-commissioned after acceptance, however much work needed to be done to prepare.
  – Work with therapists establish clinical workflows
  – Work with dosimetrists to establish planning procedures
  – Establish physics quality control program
  – Final commissioning work
    • Beam scanning with water tank to verify profiles and depth doses
    • TomoPhant_5set dose calibration verification
    • TG-51 output
    • External TLD audit
    • IROC phantom test
  – Establish patient treatment plan QA procedure
    • Sun Nuclear ArcCheck™
TomoPhant_5set plans

• The golden standard for output calibration
  – 10 plans, 6 measurement points per plan, minimize the difference between measurement and calculation of all points

• Performed during commissioning, output adjustment, machine revision, and major service

![Calculated & Delivered Dose graph]
Physics - Daily QA

• TQA™ Daily QA is performed every day during warm up.
  – Data trends are reviewed by physics

• Output, field symmetry and flatness measured every day with Sun Nuclear TomoDose™ and monitored with Daily QA™3 software
Physics Monthly and Annual

• Used AAPM TG-148 guidelines for tests, frequency, and expected tolerances.
  – Newer technology not discussed in report will need testing also:
    – Static gantry treatments
    – Running start/stop y-jaws

• TQA™ Software can be used for a lot of the recommended tests.
  – Monthly – monitor chamber constancy
  – Monthly – rotational output variation
  – Monthly – transverse profile

• TQA™ Daily QA trend report included with monthly report
Weekly Chart Checks

- Aria™ Chart QA unavailable for physics weekly chart checks
  - Typically we task chart checks throughout the week and check them through Aria Chart QA

- Physics weekly chart check for patients on the Radixact™ System are tasked in Aria™ for Friday morning 6 AM.
  - This groups all the patients on the Radixact™ System into an easily identifiable time group

- Therapist prints patient treatment summary PDF every Thursday after treatment
  - Physicists have Thursday and Friday to complete weekly chart checks
Weekly Chart Checks

- Physicist uploads the Radixact™ System treatment summary into Aria™ and signs off on document as Physics weekly chart check.

- Physicist weekly check items:
  - Confirm “MU” delivered did not deviate more than 1% (usually less than 0.1%)
  - Confirm partial treatments were completed
  - Correct dose reporting in Aria Reference Points
  - Review image registrations and corrections
Adaptive Radiation Therapy

- PreciseART™ option provides an automated workflow for monitoring dose delivered to patients
  - Daily and cumulative dose
  - Report mechanism with customizable trends and alerts

- Work in progress – validation and commissioning of ART software
  - Phantom tests to verify the accuracy of dose calculations
  - Comparison of dose calculated on CTrue™ image guidance and kVCT patient images
  - Accumulation of patient data to determine appropriate ART dose monitoring criteria and automated reporting
  - Evaluate the efficacy of using CTrue™ images in lieu of kVCT for replanning
Summary

• A Radixact™ System can co-exist seamlessly in a Varian environment.

• Integration of the Radixact™ System into our clinic was successful largely in part because of preparations, training, and excellent support from Accuray Incorporated.

• Physicians are pleased because there was little disruption to the workflow they are accustomed to.
  – Physicians especially impressed by the target dose homogeneity in treatment plans!