Clinical Implementation of Offline Adaptive Capability

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Disclosures

- Varian has provided compensation for me to attend this meeting
About Northside

• Currently operate 4 radiation oncology centers
• Treating over 11,000 patients per year between all 4
• 10 Linear accelerators
• 3 HDR systems
• GammaKnife Perfexion
• Velocity
• 9 physicians
• 6 physicists
• 9 dosimetrists
Overview

• What is Offline Adaptive?
• How did we implement it?
• The workflow
• Case Studies
What is Offline Adaptive capability?
What is Offline Adaptive?

- Offline Adaptive is the process of using a CBCT to generate a synthetic planning CT in order to calculate dose that was delivered.
- The goal is to evaluate what was actually treated versus what was planned.
- This information can be used to determine whether a patient needs to be re-scanned/re-planned.
- You can also use it to calculate and sum the delivered dose throughout the entire course of treatment.
Synthetic CT

• The “synthetic CT” is generated by utilizing deformable registration, along with the CBCT, to propagate anatomical changes onto the planning CT
• In this way you can use the anatomy from the CBCT, with the HU from the planning CT
• This is beneficial, since calculating dose on a CBCT is generally thought to be less accurate
Deformable registration

- Rigid registration: allows the secondary volume to be translated and rotated as a whole, to best line up with the primary volume
- Deformable registration: warps or distorts sections of the secondary image to better align with the primary image
Rigid fusion
Deformable fusion
QA tools
Implementation
Quick Background

- Somewhere around July 2015 we got the news that we would be purchasing Velocity
- We made 2 site visits
- Made a list of expected workflow improvements
- Made a list of process/workflow questions
- Fast forward several boring IT conference calls
- Velocity was installed May 2016
Rollout

- We decided to roll out Velocity in phases, since our hospital is so large
- Two of the four clinics were trained first, with on-site Varian trainers
- The other two clinics came 2 weeks later
- Staff trained included physicians, physicists, and dosimetrists
  - Dosimetrists got the most comprehensive training

*Have a Super User!
Progression of use

- Started with deforming PET scans – fairly simple and we do it almost every day
- That leads to deforming structures and doses
- Then some contouring tools like auto-PET, contouring scripts
- Offline Adaptive is an advanced feature
  - Difficult for physicians to get a feel for
Adaptive Workflow Overview
Rigid registration based on treatment shifts
Deformable registration
Create Synthetic Adaptive CT

Planning CT + CBCT = Synthetic CT
Planning and Synthetic CT
Dose Calculation

• The original treatment plan is then copied to the Synthetic CT in the treatment planning system, and the dose is calculated.
Compare planned vs. treated
Case Study 1

• 29 year old male with stage IV squamous cell carcinoma of the anus
• HIV+ with a large exophytic mass
• These types of masses can shrink rapidly
• Patient simulated prone with bolus
• RapidArc treatment delivery planned
Initial plan
After 8 days of treatment
Re-plan? Already??

- Does the patient already need to be re-scanned and re-planned?
- Offline Adaptive capability can help answer that question
Register planning CT to CBCT
Perform deformable registration
Create synthetic CT
Synthetic CT vs. CBCT
Send to TPS for dose calculation
Initial vs. Recalc’ed
Is this close enough? Or should it be re-scanned?
Create registrations

• Next we create a series of quick chained registrations between the planning CT, CBCT, and synthetic CT

• Then resample the recalculated dose to display on the planning CT
Dose on planning CT
Dose subtraction
Navigation tool
Dose Volume Histogram (relative)
Dose Volume Histogram (comparison)
Does the patient need a new plan?
Case Study 2

- 40 year old female with stage III endometrial cancer
- Previously received pelvic irradiation, and now returning for a paraaortic node recurrence
- Plan is to use a static field IMRT technique to deliver 45Gy to the paraaortic nodes, with a SIB of 50Gy around the positive node
- At fraction 15 the patient was re-scanned and re-planned due to a large amount of weight loss
- The day the new plan started, the patient had gained back a large amount of weight
- Now what?? Re-plan again??
Initial Plan
Weight loss at treatment 15
Subsequent weight gain
Register planning CT to CBCT
Perform deformable registration
Create synthetic CT
Synthetic CT vs. CBCT
Send to TPS for dose calculation
Dose on planning CT
Dose subtraction
Dose Volume Histogram (relative)
Dose Volume Histogram (comparison)
Does the patient need a new plan?
Case Study 3

- 63 year old male with squamous cell base of tongue
- RapidArc plan delivering 66Gy, 60Gy, and 54Gy via SIB in 30 fractions
- Noticed discrepancy in the CBCT body outline at fraction 20
Initial Plan
Register planning CT to CBCT
Perform deformable registration
Create synthetic CT
Synthetic CT vs. CBCT
Send to TPS for dose calculation
Dose on planning CT
Dose subtraction
Dose Volume Histogram (relative)
Dose Volume Histogram (relative)
Dose Volume Histogram (comparison)
Does the patient need a new plan?
Closing remarks

- Offline Adaptive capability is a handy tool that can cut out unnecessary re-planning
  - This is a benefit to the staff as it saves time
  - And a benefit to the patient as it can save treatment delays and ensure we are delivering accurate doses
  - Also, a benefit to the physician for peace of mind
- It takes time for staff to become comfortable with the steps
- The most difficult aspect is the physicians deciding what is the acceptable threshold
  - Currently it’s a subjective, case by case basis
  - Adaptive therapy is still new
Questions?