Online Adaptive Planning Strategy for 1.5T MR-Linac

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Improving Health QUALITY, Increasing Global IMPACT

EASTERN TIME [GMT-4]

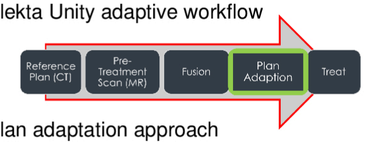
INTRODUCTION

- Elekta Unity MR-Linac
  - In-room high-field MR-guided linac
    - 1.5 Tesla MRI (Philips)
    - 7 MV FFF beam
  - Simultaneous tumor imaging with MRI and radiation treatment
  - Superior visualization of soft tissue with MRI

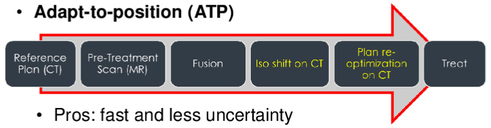
- Online treatment plan adaptation
  - Optimized plan for anatomy change
  - Precise treatment delivery

AIM

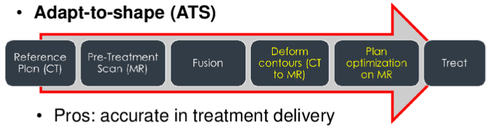
- Elekta Unity adaptive workflow



- Plan adaptation approach
  - **Adapt-to-position (ATP)**



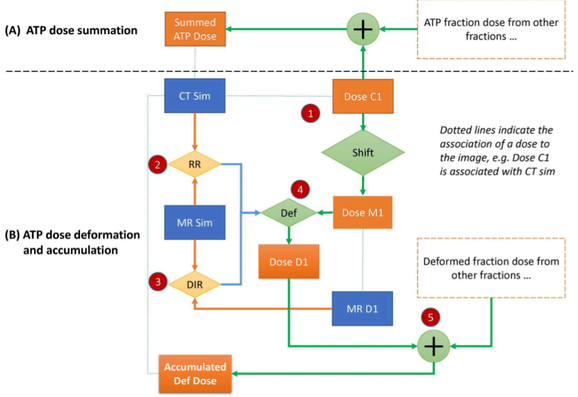
    - Pros: fast and less uncertainty
    - Cons: do not adapt to actual daily anatomy
  - **Adapt-to-shape (ATS)**



    - Pros: accurate in treatment delivery
    - Cons: time-consuming and more uncertainty in contouring and dose calculation
- Purpose
  - To stratify patients for ATP or ATS plan adaptation
  - To balance (1) accuracy of treatment delivery and (2) treatment time management

METHOD

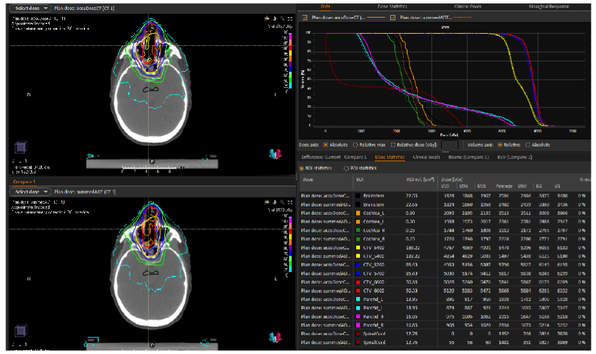
- Patient data
  - Ten patients treated at MR-Linac
    - Five head and neck patients (30-33 fractions)
    - Five prostate/pelvis SBRT patients (5 fractions)
  - All were treated with ATP for online adaptation
- Dose accumulation of ATP plans
  - **(A)** ATP dose summation
    - Direct summation of daily ATP fraction dose
    - Represent the **planned delivered dose**
  - **(B)** ATP dose deformation and accumulation
    - Dose accumulation steps
      1. ATP fraction dose shifted to daily MR space (Dose M1)
      2. Rigid registration (RR) between CT sim and MR sim
      3. Deformable image registration (DIR) between daily MR and MR Sim [1,2]
      4. Combined RR and DIR to deform "Dose M1" to CT sim space (Dose D1)
      5. Summation of deformed fraction dose (Dose D1) to create accumulated deformed dose
    - Represent the **actual delivered dose**
- Compared summed ATP dose (A) with accumulated deformed dose (B)
  - Evaluated the accuracy of delivered dose using ATP approach
  - Decide the adaptation strategy for selected patients



RESULTS

- Head and neck cases
  - Primary target dose difference was within 1% except one patient (3%)
  - Most organs-at-risk (OARs) receiving substantial dose had a difference less than 10%
  - Small structures (e.g. cochlea and carotids) tended to have large difference
  - Anatomy change in the long treatment course might have significant impact

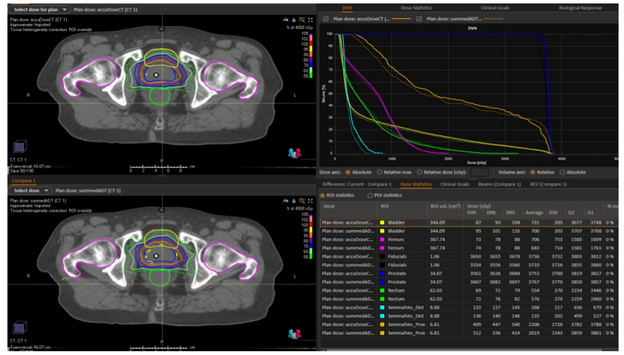
Comparison between accumulated deformed dose (top left) and the summed ATP dose (bottom left) for one head and neck patient. Dose volume histogram comparison is shown on the right panel. The target dose and most OAR dose are consistent between these two dose distributions. Only left cochlea showed about 5% difference.



- Prostate/Pelvis SBRT cases
  - Target dose difference was within 0.5%
  - Most OAR dose was low and the absolute dose difference is < 1 Gy

Case	Prostate / GTV			Rectum/Bowel			Bladder		
	D_{ATP}	D_{DEF}	DIFF	D_{ATP}	D_{DEF}	DIFF	D_{ATP}	D_{DEF}	DIFF
Prostate #1	41.52	41.39	-0.3%	11.16	15.12	35.5%	4.77	4.52	-5.2%
Prostate #2	37.21	37.18	-0.1%	7.06	6.67	-5.5%	16.58	16.09	-3.0%
Prostate #3	37.67	37.53	-0.4%	5.76	5.54	-3.8%	7.00	7.31	4.4%
Pelvis #1	44.78	44.75	-0.1%	9.14	8.69	-4.9%	2.31	2.01	-13.0%
Pelvis #2	42.09	42.14	0.1%	3.90	3.00	-23.1%	-	-	-

Comparison between accumulated deformed dose (top left) and the summed (ATP) dose (bottom left) for one prostate SBRT patient. Dose volume histogram comparison is shown on the right panel. The dose to prostate, bladder, rectum, and seminal vesicle were consistent between these two dose distributions.



CONCLUSIONS

- ATP approach can provide accurate dose delivery in most cases
- ATS approach is recommended only in the following situations
  - OARs that move day to day receive substantial dose
  - Patient anatomy has significant changes during a long treatment course (e.g. 30-33 fractions)

REFERENCES

[1] **Wang H, Dong L, Lii MF, Lee AL, de Crevoisier R, Mohan R, et al.** Implementation and validation of a three-dimensional deformable registration algorithm for targeted prostate cancer radiotherapy. *Inte61:725-35rnational Journal of Radiation Oncology*Biology*Physics. 2005;*.

[2] **Ger RB, Yang J, Ding Y, Jacobsen MC, Fuller CD, Howell RM, et al.** Accuracy of deformable image registration on magnetic resonance images in digital and physical phantoms. *Med Phys. 2017;44:5153-61.*

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CONTACT INFORMATION

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