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Unique Considerations When Delivering Radiation Therapy Treatment to a Pregnant Patient: Inadvisable Delivery of Noncoplanar Beams

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ABSTRACT

Purpose: To provide an early assessment of the use and usefulness of a new helical tomotherapy online adaptation emulator tool.

Methods: This study investigated the use the AdaptLTE online adaptive radiotherapy emulator tool powered by Accuray Cenos, for retrospectively evaluating previously delivered Precision Radixact tomotherapy treatment plans against original therapy objectives. Clinical planning CTs, structures and treatment plans with their corresponding daily pre-treatment images and setup/registration parameters were imported into the AdaptLTE system and used to emulate online adaptive treatment processes.

Results: Preliminary evaluations of 157 treatment fractions from 9 female pelvis treatments. Dosimetric quality of adapted treatment plans often exceeded the quality of simply recalculating the planned treatment on the daily image, and some adapted fractions also achied improved plan quality metrics compared to the initial treatment plan calculated on the planning CT. Further work is currently underway, to evaluate how the results of using the Radixact online adaptive system (ie. the adapted treatment plans that would be selected for delivery to patients) may be affected by different decisions made by different users during the adaptation workflow.

Conclusions: Access to the AdaptLTE emulator system allows multiple users to rerun and compare results for specific treatment fractions, enabling systematic investigations of the performance of the Radixact online adaptive radiotherapy system to be completed without affecting or delaying the treatments of any current patients.

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INTRODUCTION

The Accuray Adapt LTE ("learn trial evaluate") workflow emulator was released in 2025. This study communicates the early experiences of a multidisciplinary team learning, trialling and evaluating the system for potential future use as part of a Radixact (Accuray Ltd, Sunnyvale CA, USA) online adaptive radiotherapy system.

METHODS AND MATERIALS

Preliminary evaluations were completed using 157 fractions from 9 female pelvis treatments. For each emulated treatment fraction, AdaptLTE automatically deformed contoured structures and calculated a corresponding dose distribution on the daily image for that fraction. Users had the option of accepting or editing contoured structures, accepting the initial treatment plan or re-optimising the treatment plan based on the new structure geometry.

OBSERVATION: Anatomy

It was observed that daily anatomical changes affected radiation dose delivery in pelvic radiotherapy. Taking the bladder as an example, in these female pelvis treatments:

- Bladder volumes varied significantly between 15% smaller to 11% larger than planned although the majority were smaller
- Smaller bladder volumes caused significant increases in high-dose bladder metrics such as V(45 Gy) compared to reference plans (see Table 1)
- Plan adaption reduced bladder dose, often restoring V45Gy below clinical thresholds within the initial adapted plan
- In fractions with increased bladder size the adaption could degrade bladder metrics

Table 1. Example dose calculations relative to high-dose bladder constraint for the initial ("Reference") treatment plan, the dose calculated on the registered daily image ("Daily") and the results of adaptation ("Adapt 1", "Adapt 2"), for sample fractions from three treatment cases.

Case	Planning constraint, bladder	Reference V(45 Gy)	Daily V(45 Gy)	Adapt 1 V(45 Gy)	Adapt 2 V(45 Gy)	Volume change
FP9#1	V(45 Gy) < 35%	22.1%	45.0% ↑	25.0% ↓	N/A	-15%
FP9#2	V(45 Gy) < 35%	22.1%	48.0% ↑	25.0% ↓	N/A	-6.4%
FP9#3	V(45 Gy) < 35%	22.1%	47.5% ↑	24.4% ↓	8.4% ↓	-4%
FP9#15, replan	V(45 Gy) < 35%	27.0%	7.7% ↓	24.4% ↑	7.1% ↓	+11%
FP8#9	V(45 Gy) < 35%	9.9%	53.3% ↑	8.7% ↓	N/A	-10%

OBSERVATION: Adaptation

Dosimetric quality of adapted treatment plans was expected to exceed the quality of simple mapping of the planned treatment onto the treatment-day anatomy, while likely not achieving the quality of the initial treatment plans on the corresponding planning CTs. While the former was usually observed to be true, the latter expectation was occasionally exceeded. There were some aspects of some adapted fractions that achieved improved plan quality metrics compared to the initial treatment plan. This was an unexpected, though understandable, result of the occasions where the patient anatomy shifted into arrangements where treatment goals were more easily met than on the day of the initial planning CT. (See Figure 1(a) and (b).)

Figure 1. (a) Result of recalculating the initial treatment plan ("Reference") onto the registered daily image ("Daily"), showing the poorer dose-volume metrics that would have arisen from delivering this treatment without adaptation. (b) Result of re-optimising the treatment, with respect to the structures contoured on the daily image ("adapted"), showing improved dose-quality metrics compared to the initial plan recalculated on the daily image as well as (for the sigmoid colon and bladder) compared to the initial treatment plan.

OBSERVATION: Contouring

Experienced tomotherapy planners found that when using AdaptLTE it was best to limit the number of OAR contours that could be edited:

- For the female pelvis cohort, restricting editing to just the bowel and bladder was usually sufficient.
- The necessity of also editing the rectum contour depended largely on PTV location.

Time required to edit the bowel contour was substantially affected by whether a bowel bag was used in the original treatment plan or individual bowel loops had been contoured.

The importance of using a consistent contouring protocol at the initial treatment planning stage was quickly recognised as a key requirement for consistent and reliable use of an adaptive workflow such as AdaptLTE.

OBSERVATION: AI vs deformable

AI-driven contours were able to accurately outline well-defined pelvic organs but may require manual correction for complex anatomy. Further investigation is needed beyond the limited range of structures available in pelvic region.

Deformable contours preserved anatomical relationships but were seen to occasionally falter in the presence of significant shape or volume changes - very important for bowel.

Even minor contour changes impact dose metrics, making expert manual review essential in online workflows (of both contours and dose).

CONCLUSIONS

Preliminary investigations of adaptive tomotherapy delivery enabled though the AdaptLTE system have highlighted the importance of adhering to contouring protocols at the treatment planning stage, and pre-defining guidelines for contour editing and scrutiny at the treatment delivery stage, for safe and efficient routine clinical implementation of an adaptive radiotherapy programme.

Access to the AdaptLTE emulator system allows multiple users to rerun and compare results for specific treatment fractions, enabling staff education and systematic investigations of the performance of the Radixact online adaptative radiotherapy system to be completed without affecting or delaying the treatments of any current patients.

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