Plan quality comparison between a C-arm linac and a PET-linac on pancreatic cases to consider known abdominal imaging advantages

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Purpose / Objectives

- The RefleXion linear accelerator, manufactured by RefleXion (Hayward, CA) uses a biology-guided radiotherapy (BgRT) platform that integrates a linear accelerator with a positron emission tomography (PET) and computed tomography (CT) technology
- The linac utilizes a ring gantry composition, rotating at 60 RPM, and generates a 6 MV FFF beam shaped using a binary multi-leaf collimator and a pair of Y-jaws with clinical openings of 1 cm and 2 cm
- The machine is equipped with a 16-slice on-board fan-beam kVCT along with a dual-ring on-board PET imager
- For non-PET cases, the fan-beam kVCT offers superior, diagnostic quality images compared to cone-beam CTs (CBCTs) on C-arm linear accelerators
- This is particularly useful for abdominal treatments where conventional CBCT image quality in that region makes it hard to localize a patient without the presence of a stent or other landmarks
- Figure 1 shows representative examples of abdominal imaging for (a) RefleXion fan-beam kVCTs and (b) C-arm CBCT with the PTV contour outlined
- Although RefleXion's imaging allows for good abdominal localization, the beam shaping tools are different than other C-arm and ring linear accelerators. As a result, achievable dose distributions from the RefleXion may be different than other linear accelerators
- The purpose of this study was to evaluate plan quality generated on the RefleXion to those generated on a C-arm linear accelerator for conventional pancreatic treatments. DVH statistics were used as a tool for comparison

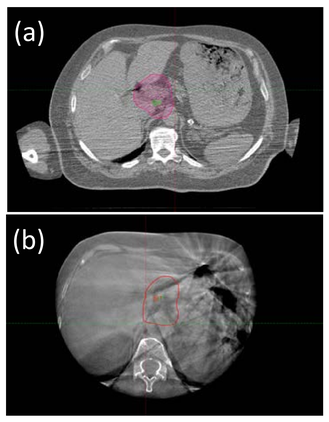

Figure 1: Examples of abdominal imaging using (a) RefleXion fan beam kVCT and (b) C-arm CBCT

Methods and Materials

- Five plans that were planned on the RefleXion linear accelerator (using X1 treatment planning system) were replanned on a Novalis TX or a TrueBeam C-arm linear accelerator using Eclipse (Varian Medical Systems, Palo Alto, CA)
- Each plan used 6FFF or 6X SRS energies and consisted of 2-3 full treatment arcs
- Planned dose was 180 cGy per fraction by 28 fractions for a total planned dose of 5040 cGy
- Optimization objectives were identical for the RefleXion plan and the C-arm plan
- The following were evaluated when comparing the RefleXion plan with the C-arm plan:
  - Target coverage (GTV, ITV, and PTV V100)
  - Liver (mean dose)
  - Large Bowel (max dose)
  - Small bowel (max dose, V50Gy, and V45Gy)
  - Left Kidney (mean dose)
  - Right Kidney (mean dose)
  - Total kidney dose (V20Gy)
  - Stomach (max dose, V50Gy, V45Gy)
  - Spinal canal (max dose)

Results

- Table 1 shows the average (N=5 plans) DVH statistic achieved by Eclipse and RefleXion plans

Table 1: Planning constraints, goals, and average statistics achieved by Eclipse (C-arm) and RefleXion plans

Structure	Constraint	Planning Goals	Units	Eclipse	RefleXion	Difference
GTV	V100	≥100%	%	100.0	99.9	-0.1
ITV	V100	≥ 95%	%	94.9	93.0	-0.4
PTV	V100	≥ 95%	%	88.8	86.8	-2.0
Liver	D_{mean}	≤ 2800 cGy	cGy	1132.5	1257.5	125.0
Bowel_Large	D_{max}	≤ 5500 cGy	cGy	3947.6	4032.0	84.4
Bowel_Small	D_{max}	≤ 5400 cGy	cGy	5264.7	5288.7	23.9
	V50Gy	≤ 10 cm^3	cm^3	21.5	19.6	-1.9
	V45Gy	≤ 135 cm^3	cm^3	43.4	49.0	5.6
Kidney_L	D_{mean}	≤ 1800 cGy	cGy	1303.8	1406.1	81.8
Kidney_R	D_{mean}	≤ 1800 cGy	cGy	881.6	1022.9	113.1
Kidneys	V20Gy	≤ 30%	%	9.5	11.6	2.1
Stomach	D_{max}	≤ 5400 cGy	cGy	5294.7	5299.7	5.0
	V50Gy	≤ 5 cm^3	cm^3	22.3	24.9	2.6
	V45Gy	≤ 75 cm^3	cm^3	37.5	46.8	9.3
Spinal Canal	D_{max}	≤ 4500 cGy	cGy	2136.0	2273.0	137.0

- Figure 2 shows a sample axial slice with a dose distribution from a RefleXion plan, on the left and a TrueBeam plan, on the right

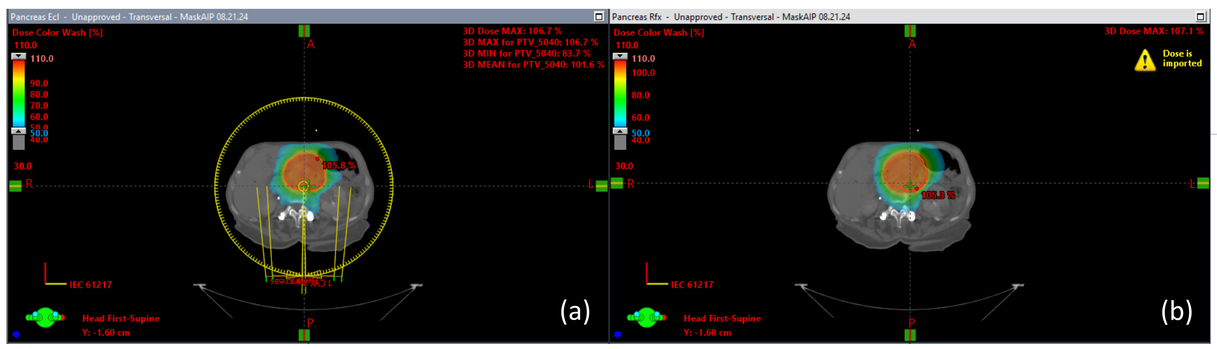

Figure 2: An example of an achievable dose distributions from (a) RefleXion and (b) TrueBeam

Discussion

- In general, RefleXion plans showed a decrease in target coverage and an increase in OAR coverage when compared with Eclipse plans delivered on C-arm linear accelerators
- There was no instance in which a RefleXion plan could not meet a planning goal, in which an Eclipse plan met the goal
- For abdominal imaging without the presence of a stent or fiducial, RefleXion offers the capability of using an on-board imaging that has superior image quality when compared with C-arm linear accelerators.
- Future work aims to expand the study to abdominal SBRT treatments (pancreas and liver) as it can compare steep falloffs between the two systems
- With new emerging technologies that improve imaging on C-arm linear accelerators, the investigation can be expanded to compare image quality and registration confidence

Conclusions

- This work investigated plan quality comparisons between readily available linear accelerators in the author's department. The ultimate goal is to provide guidelines on planning and delivery, in which imaging on the RefleXion may be beneficial for patient positioning through image registration
- Additional studies need to be completed to show the benefits on imaging and plan comparison for different types of plans

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